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The Democrazation of Industry, or Enlightened Methods of Treating the Employed.*

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I am going to talk to you to-night on what I call "Enlightened Methods of Treating the Employed." I say "enlightened" methods to distinguish them from those which belong distinctively to the past and are now being gradually given up as obsolete.

It does not need any proof, in fact, it is a commonplace, to say that this old world of ours is forever changing for the better. There is a force that down through all the ages has continually made for progress, and as in all the different arts and sciences that have brought about our present civilization, there have been development and improvement, so in those which affect the government of nations entering into that civilization there have been, more than in all the rest, changes for the

*A lecture delivered before the Franklin Institute and the Young Men's Christian Association, January 19th, 1906.

better. No people should appreciate this statement more than you as residents of Philadelphia, who have just passed through a change in your municipal government from a bad to a better condition of affairs, and you should understand that government of the many, as in a municipality, does not differ in the principles of the art, from the government of the few, as in a commercial enterprise. In either case, a large group of individuals is formed, to accomplish certain results and this group is governed and directed by a smaller group.

Individual wash basins and wire clothes lockers, lavatory of Weston Electric Instrument Co., Newark, N. J.

The art of government is as old as the human race. In early times the type of government was patriarchal, with the strongest man of the tribe at its head, and this was the prevailing type for centuries, and it was ideal, as long as the tribe was small, for the leader knew each member and all could council together as a family; but as the tribe grew in size these close relations were no longer possible, and the leader was precluded from associating with the many. He then surrounded himself with his favorites as advisors, built up his army, and

his church, assessed the tribe for their support and his permanent authority was established. This was the second stage in the development of government. It assumed the shape of a military organization with generally a tyrant at its head.

Now it is a law of ethics that the abuse of power which almost always accompanies its possession, generally leads to its overthrow, but so strong is habit and so tenacious our hold upon tradition, that successors have always followed in the beaten path with only such restrictions to their authority as their outraged subjects dared to institute. But great evils gradually bring about conditions which ultimately effect a cure. At last the people, restless under tyranny, realized their power and began to exercise it by forming political parties and injecting into the art of government the principles of democracy, a word derived from the two Greek words—*demos*, the people, and *kratein*, to rule. Thus has come about the third and last stage of government, "Of the people, by the people, for the people."

A long, tedious struggle it has been to break the fetters which have chained men to the past, but history shows that the tendency has been towards democracy in all directions. First, religious democracy, giving every man the right to worship God according to his conscience. Second, political democracy, giving every man a right to have a voice in making the laws which govern him; as our Declaration of Independence puts it—"The right of every man to life, liberty, and the pursuit of happiness." And these changes have come about through education, through teaching men and women to think. And now, thirdly, we are witnessing the advent of industrial democracy.

Industrial establishments have until very recently been run on the patriarchal system of government. Until the introduction of machinery they amounted to small aggregations of people all of whom were on terms of intimacy with the owner. The interests of master and men were understood to be closely identified and often led to family ties. Those were days of wholesome toil for both the employer and employee, the former being as skilled in the craft as any of his workers. But the growth of industrial enterprises became phenomenal when the steam engine revolutionized methods of manufacture, and the great numbers of employees which constituted their work-

ing organizations have made the employer a stranger to his help.

Thus the second stage of the development of industrial government arrived, and the man in control being the possessor of power, promptly assumed the role of dictator and oftentimes became a tyrant. The inevitable exercise of undue authority has led to resentment in the industrial field as it had in the others, above mentioned, and the industrial revolution led by those whose interests were common brought about the trades unions, which have for some years been forcing a change to methods which are more democratic. Employers took little heed of history when they ground down their workmen until they organized for mutual protection and then punished them for organizing.

We are all too prone, in the freedom of democracy, to feel that the possession of rights gives us license to do as we choose, or at least as much as we are allowed to do. This tendency has brought about laws for our restraint. The employer can no longer do as he pleases. He must either counsel with his men to find out what they need, or what they want, or he will receive the information by a more indirect though no less positive channel. But there are still moral restrictions which cannot be embodied in the law and these, we are now learning, are equally essential of observance in the growth of a successful democracy.

For instance, by parity of reasoning, if one has the right to vote, has he not a right not to vote, or to sell his vote, or to stay at home and let someone else vote for him? If he has a right to run for office, has he not a right to use that office for private gain, or to do just as he pleases with it? If he enters business, has he not a right to run that business as he chooses? By no means. There has been too much of this kind of reasoning. We must learn, and we are rapidly being forced to the realization, that in every individual right there are duties to others involved. That if one assumes a duty it becomes not only a privilege but an obligation. Inalienable rights mean inalienable duties. The sovereignty is in the people. The latter are becoming educated and in education is salvation.

Of late there has been a moral awakening to our obligations,

Billiard room in Recreation Hall.
Weston Electric Instrument Co., Newark, N. J.

there has been an ethical trend to affairs, religious, political and industrial. We have in our religious circles settlements formed for social betterment, in our political affiliations, we have federations for civic betterment and in the world of commerce we have institutes for industrial betterment.

There are various devices for improving the condition of our shops, and methods of treating employees to carry out the ethical method of management, all of which are recognized as safe of application, provided they are appropriate to existing conditions. The devices referred to found their beginnings in Germany towards the latter part of the last century. They con-

Wash basins and shower baths.
Cleaveland Cliffs Iron Co., Ishpeming, Mich.

sisted in well lighted work rooms—cooled in summer and warmed in winter, bright, cheerful and comfortable lunch rooms where the workers could obtain a wholesome and substantial meal at a nominal cost, emergency hospitals where first aid to the injured could be administered, rest rooms for the temporarily indisposed, reading-rooms where the best literature, both popular and technical, could be obtained, lectures and classes for the instruction of those who desired to improve and advance themselves in the works, organization, clubs, gymnasiums, baths, beneficial organizations, pension systems, etc.

Bulletin board and suggestion box
Nernst Lamp Co., Pittsburg

The fact that these features produced and attracted better workmen and that better product resulted became obvious to enterprising American manufacturers who were traveling abroad in search of new methods for meeting competition, and it was not long before they were tried out under conditions as they existed in factories in this country, and were rapidly adopted, as soon as their paying qualities were demonstrated. These features as they had been introduced originally in Germany under the paternalistic proclivity of the government had received the designation "Wohlfahrts Einrichtungen," or Welfare

First aid to the injured. Hospital room
J. H. Williams Co. (Drop forgings) Brooklyn, N. Y.

Institutions. This phrase has been badly translated into English as "welfare work," and gives to those to whom it is applied a feeling that they are objects needing special treatment, which is an unfortunate interpretation of their present purpose. But these features are merely initial steps in the industrial betterment movement referred to.

Good wages and the good will of the employer and of the management must accompany their introduction or they will

District Sales Managers Banquet at Annual Meeting,
Nernst Lamp Co., Pittsburg, Pa.

not accomplish their purpose. In other words, Industrial Betterment will fail utterly unless the spirit of loyalty infuses the whole organization from employer down to the least paid employee. It is the introduction of this spirit that requires the highest intelligence and a thorough understanding of human nature. It is hard to realize the attitude of mind necessary to successfully introduce betterment into a shop where nothing of the kind has ever been considered. All preconceived ideas as to how shops must be organized and managed have to be revised.

Our system of preparation for service has grown so fast that they have never gotten into joint and have not harmonized. We try first in the public schools to educate our people to think, and when they are old enough to work we put them into factories and industrial enterprises of all kinds and then we do not take advantage of the instruction we have paid so much to give them. There they are with their power of thought more or less developed, and we do not make an effort to encourage their originality. On the contrary, we say to them, "do as you are told." "Do as someone else has planned for you," and so we do not reap the harvest that we have spent so much effort in sowing. The principles of the military form of government still persist where implicit obedience is required with no originality of thought.

The implicit obedience theory is wrong, for it does not enlist the will in co-operation, and co-operation is what is necessary for mutual success. Nor is this the only result. Man is by nature a thinking animal. The trouble with most of us is that we do not think independently. As I have said, we are not encouraged to do so. We think as someone else thinks or as we think someone else thinks we ought to think. And so, as the employer makes no effort to direct the thoughts of his employees, it is left for the demagogue or the yellow press to do it and then the employer wonders why his organization thinks differently from the way he wants it to and is so disinterested in his welfare.

But human nature in the employee is the same as in the employer, and when a man feels that his employer cares nothing for him or his interests, he is very apt to return that sentiment, and so the two instead of co-operating in a common interest

become antagonistic, each working for his individual interests only. The workman has come to regard his employer, who he never sees, as an oppressor who is trying to get from him all he can for the least money. The employer feels that his workmen are trying to do the least they can for the wages he gives them. That is the feeling they actually possess, although each knows that their interests are really common.

The mere increase in number, from the single capitalist, who

Library and reading room.
Weston Electric Instrument Co., Newark, N. J.

becomes the partner of a man who supplies skill to develop a project, does not alter the relations which exist when the employer has many employees. The employer and the employed are still partners. The interest of the employees in his enterprise must be secured and maintained if the employer wants their co-operation, and to do this the employer must reciprocate by showing an interest in the welfare of the employees.

Human nature is human nature without any exception. A man will do more for his friend who is doing all he can to

Girls rest room and infirmary
Nernst Lamp Co., Pittsburg, Pa.

help him than he will for one who shows openly he cares nothing for his interests. Employers who sustain relations of the first kind with their workmen testify that without such co-operation they could not have attained their present success. They testify that a minimum of friction exists, that the machine moves smoothly and rapidly and the desire on the part of the worker, to subserve the interest of the employer implies good workmanship, increased production, and therefore, greater surety to the enterprise. In other words, co-operation pays.

Assembly room
J. H. Williams (Drop forgings) Brooklyn, N. Y.

This is only common sense, we have known it always, but we have waited for the twentieth century to come before practicing it.

Intelligent provision for the best conditions of comfort and best facilities for producing work results in attracting the best grade of workers, who are capable of the best service, a mutual uplift is accomplished, an environment is secured in which the antagonist, the idler, the incompetent, become eliminated by their own initiative. In other words, the more capable the

individual and superior his facilities the better will be the accomplishment. As Walt Whitman said, "Produce great people, the rest will take care of itself."

These ideas are not new. They are as old as the human race, and yet they have been practiced rarely and only when employers have realized their civic and moral responsibilities and knew how to meet them. The inertia of selfishness is great. Men wish to keep all they have and grasp for more, and it is usually competition or intensified self-interest which awaken them to adopt means other than they are accustomed to, to protect their interests.

Lockers and clothes drying racks.
Cleveland Cliffs Iron Co., Ishpeming, Mich.

Those employers who have come to see that they are not sufficient unto themselves, but by the assistance of their fellows and through their co-operation have attained success, have opened the eyes of others more conservative to a realization of the fact that if they desire to win the race they must adopt a more enlightened policy of action.

And yet there are many who are still incredulous of what they have been told of the success which follows the application of these common sense principles. They have hesitated to accept the evidence which has been presented to them. Now, to accept theories without practical tests is manifestly unsci-

Salesmen's school in factory. Nernst Lamp Co., Pittsburg, Pa.

Salesmen's school in factory. Nernst Lamp Co., Pittsburg, Pa.

entific and dangerous, but to reject the facts when the evidence is plain is equally unscientific and dangerous. Science and wisdom lie respectively in the detection and acceptance of the truth, not in the rejection of it, and it is possible to err by rejecting truth as well as by accepting what is false. Of the many persons who are inquiring into the new order of things there are some who see the benefits that accrue by the adoption of the methods advocated, yet there are others who have felt

Automatic Jet Drinking Fountain.
In use in many factories.

that they would rather wait until they could afford to be generous to their employees. But these are being told that success is the outcome of close relationship, and not the reverse. It is this awakening of the industrial world to the touch of the democratic and ethical trend of affairs that is new, and the spread of the thought is rapid. It is the application of these principles, however, that is difficult.

It was easy for the man to whom these ideas were natural to keep in touch with his workmen. But how is the other man

to make the change? How is he going to alter his attitude of aggression to one of persuasion and co-operation? Will he frankly acknowledge his mistake? Will he not at once excite suspicion that he has some new scheme to work? Can he hope to gain confidence by acknowledging that he has not heretofore been deserving of it?

Of course it is impossible nowadays, in most cases on account of their number, for the employer to come in personal touch with all of his employees. The details of this duty must, like all his others, be delegated to the head of a department. But the importance of that department must now be recognized by securing for it as competent a head as is provided for every other, and it must receive the same personal supervision by himself as the others.

Care must be taken to avoid paternalism in the treatment of his people. No self-respecting man will stand patronizing, nor does he wish to be looked upon as an object of charity. Co-operation must be the slogan. Not that kind that expects the other fellow to do all the co-operating, but the kind that extends opportunities for obtaining help. But care must be taken regarding the manner in which help is extended. Helping men in the ordinary sense of the term tends to weaken them, helping them to help themselves develops and strengthens their ability to advance. And it should be remembered that, as most of the waking hours of employees are devoted to their work, the effect of the employers' treatment upon them for good or bad will be great and permanent.

First of all, however, wages and hours of work must be satisfactorily arranged before any schemes of industrial betterment can be proposed. What men work for is money and until their wages are satisfactorily adjusted any reference to betterment of conditions will be taken as a proposed substitute and looked upon with suspicion.

Employees should be allowed to suggest their needs and how the latter should be supplied, rather than that their needs should be pointed out and offers made to meet them. These are democratic principles. In one case the employees ask for what they need and appreciate what they get, in the other they have not wanted what they received, and because they therefore show no appreciation of it they are considered ungrateful.

The time has passed when shops excluded the public for fear of the appropriation of ideas. Nowadays the public is invited to visit the shop, not only as a means of advertising it, but because the public actually supplies ideas to its management. Taking advantage, therefore, of the publicity accorded by representative industrial enterprises, let us visit some of them widely scattered accross the continent and see what they are doing in the nature of industrial betterment. (The speaker then showed about one hundred slides, of which a few illustrations are shown here.)

And now a word in conclusion: Remember that the democratic stage of industrial management has arrived. Do not be afraid to interest the employees in your affairs. The more you can interest them the less apt they will be to work against those interests, especially if you make it plain to them that your interests are theirs also. Men will rise to responsibilities as the latter are imposed. This principle is made use of in the School City where the children of the public schools are allowed to govern themselves. Mr. Gill, who devised this wonderful innovation says: "Give a pronounced radical authority and he at once becomes a conservative." By adopting similar principles the juvenile courts are taking young criminals in hand and by making them part of the constabulary are purifying our cities.

Sound judgment must be used in introducing these democratic ideas. The industrial field is strewn with wrecks of attempts to accomplish the desired end. Do not go at it haphazard. Get some one who has had experience to guide you till you can travel alone with safety. Methods that have been repeatedly applied are successful, but the details of treatment vary according to circumstances, so that what is pertinent in one place is not so in another. A careful study of each case must be made before deciding what to do. Be sure you are right, then go ahead. Bear in mind, however, that you are dealing with the human element, and that your responsibility in controlling and directing the lives of those whom you employ is a dual one, a privilege and an obligation. Being imbued with these ideas you will find plenty of precedent to follow in adopting enlightened methods of treating your employees.

A Trip to Easter Island.*

[A SPECK ON THE OCEAN.]

By Victor Strauss Frank.

Part I.

If you take a map of the world and place the point of your nail upon the Tropic of Capricorn in Chili and run it along the dotted line westward you will find a dot marked Easter Island.

Upon the chart the Pacific thereabouts is not pockmarked with islands or shoals, for Easter Island, or Isla de Pascua, or Rapa-Nui, or Téapy, or Te-Pito-Te-Henua claims the honor of being the most isolated island on the globe, being equidistant from *terra firma* for more than two thousand miles; its nearest approach to any Pacific island being Tahiti, some two thousand four hundred miles distant.

Mariners very seldom approach it; now and again a barque bound for the seas of Mexico sights it and notes on her log-book: "Passed Easter I. Lat. 27° 10′ S; Long. 109° 26′ W." —"Heavy Seas."

Sailors are warned to give it a wide berth, for more than one vessels has been lost on the rocks of this dangerous coast and the crews have been dashed to pieces or have fallen into the hands of cannibals and been eaten. Even of late years skippers who have entrusted the handling of their ship to the Kanakas, in expectation of being piloted to a safe anchorage and thus enabled to replenish their water supply, have seen, too late, the stratagem of the natives, and their vessel was soon reduced to firewood.

Few men ever visit this Pacific islet, so interesting from many points of view, so much so, as to induce the United States and German Governments to send scientific expeditions there. The romance with which the island of Juan Fernandez has hitherto

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*Read by title.

been invested has of late years disappeared before the march of the pioneer; Chili has colonized and peopled it with fishermen. It is doubtful that such a step will ever be taken with regard to Easter I., likewise a Chilian possession, for it is two thousand and thirty nautical miles distant from the coast of Chili, whereas Juan Fernandez is only four hundred miles west of Valparaiso.

In this brief sketch of this, the most isolated island in the world, the extraordinary, the exceptional, the sensational, are not to be found; only a description of one of the least known islands in the Pacific.

Early in November, 189—, great excitement reigned at Valparaiso; the local papers announced that the hull of the *"Maria,"* a trading vessel, overdue for more than a year, had been sighted by a homeward-bound vessel, lying high on the rocks of Easter I. The owners lost no time fitting out a ship in order to ascertain whether the hull in question was actually that of the *"Maria,"* as well as to pick up any possible survivors. A few weeks later the *"Tortuga"* (truly an appropriate name) was ready for sea. A skipper, well kown on Valparaiso quays, two sailors, one of whom styled himself cook, myself and a magnificent dog called Joey formed the relief expedition.

Our departure was somewhat ominous; no sooner had we slipped our moorings in front of Bella-Vista than a series of squalls, gales, hurricanes which followed one another in quick succession forced our craft to scud under bare poles. The skipper cursed and played "rocamber" with the crew; Joey slept; I took a turn at the culinary department!

The *"Tortuga"* was perhaps the greatest rattletrap of a vessel that ever left Valparaiso; she was as hard to steer as a pig, leaked like a sieve, rolled gunwales under at times and eventually lost her fore-topmast. (Overall: 19m80; beam: 6m25; depth: 2m26; draft; 1m80; reg. ton:88.14; gross ton: 92.77.)

To add to our general discomfort the fresh water supply ran short and salt-junk became too much in evidence on our menu. Notwithstanding our many trials, ten weeks after our departure from Chili we sighted the Rana-Kao mountains in the distance.

Dropping anchor at Hanga-Roa or Cook's Bay, the only pretence to an anchorage, and as aptly remarked by Captain James Cook, "a very poor one," we had the satisfaction of meet-

ing with a friendly reception from the natives, who had swum a mile out to meet us, shouting and gesticulating as they attempted to climb on board. Joey was called to protect us from the too gushing intruders and bravely beat them off, but not until he had left the impression of his molars on the hindquarters of several plump Kanakas. Order being at length restored, we found a sunburnt Chilian in our cabin helping himself freely to brandy and cigars (of the latter he had pocketed a dozen or more). First impulse was to throw him overboard, when, not in the least disconcerted, he introduced himself as "The Inspector-General of Colonization for the Chilian Government," and in a most courteous manner offered us full hospitality on shore. He also informed us that the "*Maria*" had been wrecked on the island, but that four of the crew had been saved.

Easter I. was, after all, not such an inhospitable place as we had been led to expect; officialdom was *en evidence* and that sufficed to induce us to go ashore! Not heeding, however, the warning of the Inspector-General of Colonization for the Chilian Government to trust our persons in a native canoe, we put off in our only whale-boat, which was manned by three Kanakas. The shore was enveloped in a dense mist and, what with the roar of the surf on the bar, the boat rocking as in a churn, the impression was far from pleasant for a land lubber. Suddenly a wave more erratic than the rest came rolling and gambolling along and breaking alongside of us caused our boat to capsize. Words cannot express our disgust (delight on the Kanaka side) when we found ourselves in the water; the European swearing shockingly as he saw the valise containing his personal wearing apparel disappearing; second thought prompted him to look after No. 1, when the recollection of having seen sharks at sea flashed across his usually dull brain. Abandoning worldly possessions we made for shore, no easy matter, for the sea was rough. When we reached shore, much bruised, the Kanakas were disputing as to the distribution of my belongings which they had rescued. Two shirts were already turned into eight ladies petticoats. Happily the Inspector-General of Colonization for the Chilian Government saved me from the unpleasant prospect of visiting him in a nude condition by forcing the Kanakas to restore a portion of the contents of the valise, which that did with ill-disguised regret. I had, however, the satisfaction

of saving a collar, one sock and a handkerchief. I blessed that 'kerchief. Very tired, ill-tempered, we were all dragged to the Mission House, or rather to the remains of what was once upon a time a mission station, at a place about one and a half miles from Hanga-Roa. Here the crew of the *"Maria"* were discussing the event of our arrival. The lazy scamps had been on the island nearly a year, feeding upon the fat of the land, awaiting the time when a vessel should come to pick them up. Upon learning of our arrival, their satisfaction was so small that they did not trouble to walk down to the shore to meet us. At Valparaiso masses had been held for them and candles burnt *ad. lib.* Next morning, with rueful countenances, they were sent aboard the *"Tortugá"* and peremptorily ordered to assist in repairing the schooner, which was so badly damaged that it would require at least a fortnight before she could put to sea.

Part II.

Any position more lonely than that of Inspector-General of Colonization for the Chilian Government at Easter Island is impossible to conceive, and it requires a vigorous effort of the mind to believe that a man can be found to live on this remote island with Kanakas, dependent on a few passing ships for news, tobacco, matches and clothing, for the sum of 10 dollars per month. When Mr. X, a Valparaiso merchant, leased this island from the Chilian Government for a period of twenty years, paying annual tribute, and pledging himself to look after the welfare of the Chilian subjects on the island, and send a vessel there at least once every two years, he was at a loss whom to send to look after his interests. He advertised, and in response came Mr. A. This gentleman was accepted, being a man of no mean capacity, and in order to inspire his future subjects with some idea of his elevated functions as Viceroy of Easter Island, he obtained a commission from the Santiago Government appointing him Inspector-General of Colonization for the Chilian Government. Mr. A. started off in high glee and with the best wishes from his newly married wife. Poor fellow! for no sooner had he arrived on the island than he discovered his post to be no sinecure, and to add to his chagrin, found his official position ignored by Riro-Roko, King of Easter Island. Some

weeks later Mr. A. was obliged to exchange his resplendent uniform for wood; a month later he was at "dagger's drawn" with the King, who forbid him to wash in soft water—not even once a month. Mr. A. found he was responsible for the care of immense herds of cattle, horses and sheep, roaming wild over the island. He found no dwelling and had to run up an apology for a house, which was built off the ground upon hewn stone slabs, three feet thick, forty-five feet wide and nine to ten feet long, evidently the remains of an altar erected by an extinct race.

The panorama which this shanty commanded, situated at Mataveri, near Hanga-Piko, is most picturesque. The Inspector-General of Colonization for the Chilian Government passed his time eating, drinking and sleeping; he attempted to cure green tobacco, which grows on the island, and made a signal failure. He had books, but never read. His indolent disposition forbade all agitation of a topic whose interest he himself had never existed, namely, the curious and weird remains and ruins on the island. It may surprise the reader to learn that this very worthy official had never troubled to go round the island, much less ascend the craters or examine the ruins. And, to those who love a long record of an official's faithful services to his country and who have not yet learnt of the degree of *dolce far niente* a Chilian is capable of, this genial personage may be commended as a pattern official second to none.

Easter Island presents nowadays, from many points of view, a totally different aspect from that offered at its discovery by Jacob Roggewein, the celebrated Dutch navigator, who on Easter Day, 1722, with three vessels, the "Eagle," "Tienhoven" and "African Galley," carrying 271 men and 78 guns, accidentally came across this remote island which the Dutch commodore mistook for the supposed existing "Southern Continent," the inaccurate theory thereof being proved by Captain James Cook some years later. Roggewein mentions that the island was extremely fertile and densely populated, having about three thousand inhabitants. The natives, he writes, received them in a most friendly manner, offering the visitors sugar-cane, plantains, fowls and birds of every shape and hue. He says that the men were six feet in height and were pleasing

and modest and well disposed, a fact which did not prevent the Dutch from firing upon them and killing several.

The men—relates the navigator—were in the majority brown, others partly black, some white, and the latter fact appears to have made a deep impression on Roggewein, who was certain that the "terra nondum cognita" was not far distant, as Juan Fernandez was reported to have discovered in 1576 a "gran tierra firme, fertile and pleasant, the natives white, clothed in woven fabrics." Roggewein informs that the inhabitants were tattooed all over the body, the men in black, the women in blue and red. The ear-lobes of both sexes were exceedingly long and hung down to their shoulders, which he accounts for from their wearing very heavy ear-rings. The men let their hair grow long, the women likewise. Native huts, he describes, as being from forty to fifty feet in depth, six to eight feet in breadth. Roggewein noticed that the natives lighted fires at the feet of the Monoliths to appease the wrath of the visitors, also that they carried crescent-shaped shields, having human figures carved on the cusps. Space does not permit to dwell more at length on Roggewein's report. If we may rely on his statements, Easter Island was then as fertile and densely populated as it is now scantily populated.

Captain James Cook visited this island in March, 1774, and mistook it for Davis' Land, supposing it to be a certain island mentioned by Davis as discovered by him. Spanish writers claim that this island was first sighted by the Peruvian sailor, Alvaro Mendana, in 1566; others assert that Davis was the discoverer. But what is certain is that neither landed, leaving that honor to Roggewein. Captain J. Cook mentions: "This small island has only seven hundred inhabitants, of which fifteen are women, and the island will soon be depopulated." Thus, in the space of about fifty years, the island had assumed a striking transformation, which must be attributed to a visit to Easter I. by the Peruvians in 1770, when Philipe Gonzalez with two ships, the "S. Lorenzo" and "Sa. Roselia," took possession of the island in the name of Carlos III and gave it the name of the King, when a deed of possession was signed by the Kanakas chieftians, who employed hieroglyphs. The Peruvians, prone to cruelty, ravaged the fair island and in addition spread venereal disease throughout; carrying off the young

girls and fair women. La Pérouse visited Easter Island in 1786, followed by Kotzebue in 1816, Captain Beechey in 1826, by the Chilian warship "O'Higgins," by Father Eugenio Eynault and Roussel in 1863-65, by Captain Poweill in 1868, by Commander Viaud in 1871, by Admiral Lapelin in 1872, and by Mr. Thompson, (U. S. N.).

Most of the visitors, apart from Mr. Thompson, have little to say about the island, save that of praising the colossal monoliths, and more particularly the hospitality afforded to them by the ladies. It is said that some thirty years back a Frenchman had been wrecked on the island; he was not eaten for when surrounded by the natives he addressed them in Tahitian and informed them that he was a great King, that he would, however, condescend to present one of his trouser buttons to the head man of the island, but upon the express condition that no harm should be done him. Thundering forth he gave vent to a well-disguised outburst of temper, menaced that if a man dare touch him, he, Pitou-Pitou, would kill every woman on the island. His speech produced an electric effect. Pitou-Pitou, as he was affectionately called by the Kanakas, soon gained complete mastery over the island; he enticed small vessels bound for Tahiti on the treacherous reefs, scuttled them and handed the half-drowned crews to the Kanakas for culinary purposes. With the broken-up ships he built two small schooners, put a Kanaka crew on board, and traded with Tahiti, over two thousand miles distant. The French adventurer was ultimately killed by one of his many jealous wives. But his memory was for a long time cherished by all Easter Island.

We pass over in silence the occupation of Easter Island by a Tahitian firm, who deported, it is said, three hundred Kanakas to Gambier Island and five hundred to Tahiti. None returned to their native island. In the early eighties a certain Mr. B., who married a Queen of Tahiti, appears to have taken possession of Easter Island and to have sold it to the Chilian Government for the sum of 10,000 dollars, but as to the veracity of this deal I cannot vouch. The Chilian Government, *chose certaine,* occupied it, it being their intention to establish a coaling station there were vessels, en route for Australia, *via* the Panama Canal, could replenish their bunkers. The Chilians had counted their chicks before hatching, but at the time of the deal

our readers will bear in mind that the success and rapid completion of the Panama Canal by De Lesseps & Co. was assured. The Panama Canal, 15 years later, is not finished and Easter Island is left on the hands of the Chilian Government, which, after attempting to establish there a convict station, finally leased the island to a Liverpool firm, the previous occupiers having failed to pay their rent. Easter Island, in 1905, is, however, as lonesome and as much ignored by the world as at the time of its discovery.

Isla de Pascua is in the shape of an isosceles triangle with an area of about thirty-three square miles and four miles broad at its widest part. Although the island can nowhere boast of a shelter from the prevalent winds worthy of the name of harbor, yet it is surrounded by a shelving beach which at a distance of about one English mile from the shore provides a fairly good sandy anchorage interspersed with thin shingle at a depth varying from twenty-five to thirty fathoms. It is a clear coast for a mile out with the exception of the southwest point, where two small rugged islets, Mutu-Rau-Kau and Mutu-Nui, some ten cables from land, can be seen for about twelve miles off. In most places access to the shore is rendered risky by coral-reefs. A vessel can find fairly good anchorage to leeward of the island at a distance of about a mile, but precautions should be taken to enable it to put off at a few minutes notice should the wind change. Hanga-Roa, or Cook's Bay, and La Pérouse Bay afford the most security. At Hanga-Roa is situated one of the two mission stations, but in a sad state of dilapidation. This bay is not much cut out, has a bottom of fine sand, and a steamer can safely approach within half a mile from shore. There are sheltered stations, in good weather or with winds from 1st and 2nd quarters, which are the only ones allowing ships to remain in port without danger. During the winter months, or from April until October, Hanga-Roa is to windward, and it is unsafe for a vessel to remain there; the winds at this period, blowing from the 3rd and 4th quarters, are tempestuous, raising a violent sea which dashes on the rocks. La Pérouse Bay is an open stretch, two miles long, with half a curve in the most sheltered places. It offers an even bottom of the same character as the rest of the coast and a good anchorage, more exactly a "fair" anchorage, may be obtained there in

seventeen fathoms, but prudence commands standing out farther for fear of a change in the wind. Close to La Pérouse Bay, following the coast to the west, is to be found a white sandy beach, enclosed in a small bay, known as Anakena, which allows every facility for landing. Anchorage may also be found at Vai-Hou, situate in the base of the triangle, where the other mission station stands.

There is practically no tide, at any rate not exceeding one-half meter. The water surrounding the island, at the same degrees, in the same parallels, contains a greater proportion of solids than in many other latitudes. From experiments, samples taken in, gave:

Lat. 28° S., long. 98° W., 3.85 % of solids.

Lat. 27° 10′ S., long. 109° 26′., 3.91 % of solids.

These results which surpass the saline part of the known ocean, estimated at 3½%, may depend not so much on the dense evaporation of the Pacific in this zone as in the organic residues which the Polynesian waters contain and where extensive animal life and especially corals pile up vast coralline accumulations which rise day by day with wonderful rapidity, obstrucing passages heretofore navigable.

The climate of Rapa-Nui is interesting from various points of view. The island is washed by a warm current some nine degrees higher than the polar current (Humboldt) which washes the Chilean coast, and it keeps a higher temperature than Caldera and all the ports of the desert of Atacama comprised in its zone. The temperature of the air is generally one degree less than the sea so that the heat is about even day and night. Frequent rains refresh the atmosphere and the ground. The following data taken by missionaries may give a general idea as to the rainfall: April, 2 days; May, 15 days; June, 10 days; July, 15 days; August, 13 days; September, 11 days; October, 5 days; December, 5 days; January, 1 day; February and March, no rainfall.

Rainfalls are brought by N.; N.W.; N.E.; E. and S.W. winds. Incidentally we might mention that the statement made by some writers that the natives of Easter Island drink salt water in lieu of fresh is erroneous. They do drink sea water as a purgative. Easter Island is in the zone of descending clouds which, coming from the Northern Hemisphere, bring their moisture

south. All clouds which pass within reach of their attraction, collect on the peaks and condensing there, irrigate this isolated island, which has in its mountains the necessary physical conditions for precipitating the water of the atmosphere. One of its summits, the Rana-Hana-Kana or La Pérouse Mountain, is 1769 feet high; the Rana-Roraca or Mt. Topaze, 1542 feet; the Rana-Aroi or Mt. Beechey, 1323 feet; the Rana-Kao. 1327 feet. Although these elevations are not high enough to produce much rarefaction of the atmosphere, they are nevertheless sufficient to refresh the air at their summits, causing a condensation of the tropical clouds which, having passed the heat of the equinoxial doldrums, descends between the parallels which bound the temperate zone in which this island is situated. These rains, which obey the natural laws of nature, would augment with the cultivation of the island and suffice to maintain vegetation. The Kanakas rely upon natural reservoirs formed in the craters for the collection of water. The temperature in winter averages between 19-20° Cent.; sometimes as low as 16° Cent. The temperature in summer is between 26° Cent. and 29° Cent. Frosts are unknown; hail has been seen; cyclones are unknown.

For miles out at sea one is at once impressed with the mountainous nature of the island. Indeed Easter Island is remarkable for the agglomeration of volcanoes in so circumscribed an area. The island is volcanic, still, it may have formed a part of a once existing continent. The volcanoes known as Kau, Utuiti and Harui appear to have been extinct for centuries, the craters, some twelve in all, being covered with rich vegetable soil. Kau is the largest crater and nearest Hanga-Roa. It is about three hundred meters deep and the bottom as smooth as a skating rink, and the only way to account for its perfect level is that it was gradually solidified when the lava was in fusion or perhaps by the action of the sea.

Good soil is found nearly all over the island and in many places pits of vegetable soil are to be found as deep as ten meters. There is a layer of soil nearly all over the island. On the northern side sandy patches are found in thin soil where the Kanakas prefer to sow their sweet potatoes and yams. Within two miles around the craters stones are abundant in the earth and were formerly employed for the construction of huts by lay-

ing them one upon the other. There is a total absence of trees, although Roggewein spoke of palm trees. Indeed the absence of that vegetation, which one looks forward to and associates with the perpetual summer of these regions, makes Easter Island anything but inviting to the naturalist. Grass grows on the mountain slopes and in the valleys, affording pasturage to about five thousand horses of Chilian breed, five thousand horned cattle, twenty thousand sheep, the latter yielding very fine wool and lambing twice or thrice a year.

It is around the gaping chasms or fire-eaten pits of the extinct volcanoes—which, in the memory of man, have never been active, now forming reservoirs for the natives—that is found a luxuriant vegetation, growing on the perpendicular walls and at the bottom. Here a few, very few, industrious natives cultivate sweet potatoes, yams and bananas. Apart from these are found three shrubs of great utility known as Ma-huté, Borahue and Tii. The Ma-huté is a small shrub which dries up in summer to revive at springtime. It gives a stronger fibre than cotton and is woven by the natives into a strong, white texture, warm and smooth to the skin. It resembles the *Phormium Tenax* of New Zealand. The Borahue, a shrub, grows about 2½ meters high and eight centimeters in diameter; it produces a fibre-like flax which is used for string, and fishing nets, as it stands sea water well. The Ti or Tii, common to hot climates, is also abundant. The root is in the shape of an elongated bulb and is sweet, giving more sugar than the cane, which also grows on the island and is used by the Kanakas as fuel. The root of the Tii is roasted on hot stones laid in the earth where it remains several days, and, when cooked, it makes a very delicate and tasty meal. This same Tii also yields a black powder from the flower, which is employed for táttooing. The only wood found is that known as Toromiro, which, it is stated, is related to the Australian acacia. This small treeling, also called Amae, is of a reddish color, hard, heavy, crooked and does not exceed seven feet in height and the largest one-half meter in diameter. All the wooden images and few other wooden implements found on this island are made of toromiro. The zoological section is uninteresting—only rats, sea gulls and, in entomology, fleas *ad. lib.*

Round the south promontory are found huge quantities of

lobsters; they are much larger than those taken in European waters, of a deeper hue, and are furnished with prickly spines. There are but few fish on the coast line. The *cotehiva*, about 30 centimeters by 80 millimeters broad, with canine teeth; the *coveba*, about 25 centimeters by 0.65 millimeters, with no scales and a bony horn about 0.30 millimeters long in the nape of the neck. There are also flying fish and nautili. Seals or whales do no appear within ten miles from shore, probably on account of the warm currents. Turtles are abundant. There appears to be no animal indigenous to the island, but it seems that when Roggewein showed the natives some pigs he had on board they made signs that they had known this animal at some previous time. Moreover, some of the antique carvings on the wooden slabs and rocks represent hogs, birds and lizards.

Mineral wealth is absent; no traces of carbon. Here and there are found crystalline limestone and obsidian. Obsidian, according to the natives, is a gift of God to enable them to make axe-heads and chisels, but the idea of adopting them for warfare among themselves has never entered their heads, the only weapon observed apart from clubs being a quaint looking sword of "toromiro wood," two meters long, the pummel representing a god. Very heavy and sharp, this sword when wielded by an expert hand must have been somewhat dangerous.

Part III.

No opinion is formed among ethnologists as to the origin of the present generation of the Kanaka of Easter Island, and all one can venture to say is that they are fair Polynesians. The Kanakas, as the natives of this island are styled, are, the male portions of them, of fine physique, of good stature, but under six feet, slight limbed, brown black hair, rather flat noses, thickish or rather swollen lips, and good, even teeth, large hands and feet.

The women are beautifully proportioned, full of grace and other feminine attractions. Indeed we are disposed to assert that the Kanakas of Easter Island are the remaining portion of a once highly refined race. When Roggewein discovered the island there appears to have been nearly three thousand inhabi-

tants. Captain Cook estimated the population at seven hundred, but it is probable that many of the natives had retreated to hiding places, fearing lest the new comer should ill-treat them as had the Dutch and Peruvians. In 1786 the roll-call gave two thousand inhabitants; in 1863, eighteen hundred; in 1868, nine hundred and thirty; in 1885; six hundred; in 1897, only two hundred and thirteen. Polyandry, disease, emigration, alas kidnapping, have rapidly carried them off. The first practice cannot be stamped out for reasons known to the medical world. Brothers and sisters intermarry. With regard to disease, the present inhabitants are healthy, but they passed through a terrible period after the return of many of their countrymen from the Chincha, converting the island into one huge burial ground.

In 1863 the Peruvians made a descent and carried off no fewer than nine hundred natives, including the King and chiefs. The poor wretches were sent to the Chincha to work the guano fields, the women taken to Peru and when wearied by lust were sent to rejoin their countrymen. The captors ill-treated them so shamefully that a captain of a French vessel reported the atrocities to which they were subjected, to his government, which compelled the Peruvian Government to ship the Kanakas back to their home where, as the King and chiefs had been taken off into captivity, civil war thereupon raged, each trying to obtain supremacy. The King died on the guano fields, and the two hundred natives who did return were a curse for the island, as they were ravaged with hideous diseases and alive with vermin.

Frugal in their habits, their chief staple food is of a vegetarian nature. Too lazy to cook, they rarely touch mutton or beef, which are plentiful, and usually eat their fruit and vegetables raw. The cooking utensils are of the rudest description, even gourds or cocoanut shells (much prized) being rarely employed. Fingers, in lieu of forks, direct "plate" to mouth instead of spoons. They love spirits. Their resentments, though violent, are soon appeased; they are not cruel even when aroused to anger, and the island is singularly free from bloodshed. The men pass their time lolling in the sun, fishing and smoking; very few cultivate the ground; husbandry is at a very low ebb. All are expert riders and delight in breaking in the horses which roam wild over the island.

The native tongue is soft to the ear and is similar in some respects to Tahitian which the Kanakas understand. The language of Rapa-Nui only has the pronouns "I" and "You." The verbs are only conjugated by three terminations. There is no word sounded with two united consonants so the vowels repeatedly form dipthongs and tripthongs. Double "R," "W," "X," "D," "B," "S" are unknown. No word terminates in "N." To make the plural they prefix "Mau," which means "many." To form the feminine they add "toma-hina," or masculine "toma-toa." The language appears to be as easy as it is limited; they are all great talkers. They do not ignore the art of writing, the present generation having been taught by missionaries, but few can sign their names. They point out with pride to the rare hieroglyphics carved on some altar-stones, or stone slabs, but are at a loss to decipher them or to account for their presence. Several of these slabs bearing hieroglyphic inscriptions have found their way to the Museum of Santiago, Chili, presented by Father Eugenio Eynault, and one to Paris, given by a Bishop of Tahiti. They are said to refer to prayers offered to the gods and the Great Father, but the version should be subject to caution, this statement being made with all due deference for the savants who have "translated" these Easter Island hieroglyphics.

Marriage among the Kanakas is a somewhat unrefined ceremony; men have only one wife, but are promiscously licentious. Girls are kept in strict seclusion until the age of twelve, when they are claimed by the chiefs. Women have rarely more than one child and appear to be devoid of maternal love, it being a common event for a woman to dispose of her child for a piece of cloth or even for the mere asking by another woman, yet children are never ill-treated.

Subsequent to 1863 the natives of Easter Island worshipped different wooden idols or images, but not the Monoliths or Mohias which some writers mention as being statues of famous warriors rather than of deities. But on account of the resemblance of their masks, which are almost identically the same, this argument appears worthy of challenge. Their religious feasts it appears took place when shipwrecked men were cast on the island and were carried off to the sacrificial altars, usually situated at the end of a grove of monoliths. These stone-altars,

found all over the island, but especially at Rana-Kao, Vahio, Utuiti, are of immense size and made of hewn slabs carefully placed side by side, or cemented together or piled one upon the other. A few are embellished with hieroglyphs. That human sacrifice was practiced is certain; the natives do not hide the fact and inform by tradition. The numberless skulls found at Utuiti, however, do not necessarily tell a tale of cannibalism, for it was also a burial ground. Tradition says that human sacrafice constituted their highest form of worship, which one must infer was only celebrated at rare intervals, considering their isolated position. When questioned on their toromiro idols, which they carefully hide notwithstanding their departure from idol worship, they can give no answer. The idols are some, single-headed, others, very scarce, double-headed, such as the one to be seen at the British Museum. The Kanaka never was of a stubborn disposition and much less a fanatic, and when a Bishop of Tahiti sent Father Eugenio Eynault to visit the island in 1863 the worthy man met with signal success. Upon landing he was forced to make a prolonged sojourn, as his vessel had disappeared during the night, the captain remarking to the mate that it was no safe place "for a ship or Christian." As it was Father Eynoult was at once stripped and his life was only saved by the intervention of a chief. Some eight months later the Bishop of Tahiti, anxious as to the fate of his messenger of peace, sent another vessel and took him off, but the worthy Father returned two years later accompanied by another colleague, Father Roussel. The two priests worked miracles, built churches, baptized, opened a school and succeeded in forcing the Kanakas to abandon idol-worship.

Cannibalism is a practice of the past and only the very oldest men remember partaking of human flesh. Only the "Elders" were allowed to assist and came singly to the sacrifice-banquet, by different routes, at night. It was under the shadow of the huge, massive, ferocious looking monoliths that the victims, always captives or shipwrecked sailors (often Peruvians) were eaten. Wood was brought and placed at the feet of the giant gods for bonfires, so as to illuminate their strange, weird masks. At daybreak the orgy would cease and the revellers departed, making strange gestures before the clean bones and crowning

the "hats" of the monoliths with sea weed when palm branches were no longer to be found on the island.

One of their chief amusements (they love pleasure) is dancing. Men and women, young and old, gather under a grove of monoliths and, in a line, and to the strains produced by beating two sticks together or hammering on sheep skulls, dance with their knees rigid and wagging their hips in a violent manner. This pastime is in other terms a mode of seeking artificial physical excitement, but this the dancers sternly deny, asserting that it is to honor their forefathers. Tattooing is practiced, but not in so general a manner as in other Pacific islands; the custom is rapidly falling into disuse throughout Polynesia. The French Government, for instance, some years back issued a lengthy decree (proclamation) forbidding their Polynesian subjects to tattoo their bodies, and a heavy penalty is inflicted on law-breakers. The poor Polynesians now go about as naked as worms. Tattooing was a "costume." The Easter Island natives have, almost without exception, on their left cheek, the figure of a pipe in blue pigment. In the way of head dress (the chief ornament of a South Sea Islander) the beaux of Easter Island in past times were not behind other aborigines in adorning their heads with brilliant feathers, for it appears that they wore bonnets of black and white feathers of endless hue in the shape of the head of a stork. Since birds of gorgeous hue and plumage have taken their departure, the natives have to make the most of sea gulls and cock feathers, which they make up in two or three strings simply coiled around their heads. Unlike the natives of Tahiti and other Polynesian islands, owing to the absence of trees, they have not been able to indulge in the pleasures of navigation, and it has been perhaps for their good, their isolated position keeping pirates away. There are but three canoes, or pretence to canoes, built of planks from wreckage. It is highly amusing to watch them paddling in their rudely constructed crafts, then suddenly become tired of that mode of locomotion, and jump into the sea and swim to shore. Yet they make good sailors and are ready to embark on passing vessels as a part of the crew, making steady seamen, and useful in warm climes. They are all expert swimmers and fine divers, remaining under water for a remarkably long time. It is one of their principal amusements to dive after lobsters which they eat raw.

Although sharks infest these waters, not one instance of a Kanaka having been eaten by these finny monsters is recorded, but many with an arm or leg missing tend to prove that they were very near to it. Fish-hooks are made of bone and stone; although tortoise shell and pearl shells are found on the islands (more exactly on the two islets) the natives do not appear to make use of them. Unlike other South Sea Islanders spear-fishing is not practiced by them, probably owing to the depth of the water around the island and because canoes are scarce.

The King of Easter Island at the time of the visit of the *"Tortuga"* was Riro-Roko, who had paramount power over his subjects. He prided himself on his ancestry, which dates back many generations. He was a fine looking fellow about thirty, and, like his subjects, the very essence of laziness. Troubling little about his regal position, he inhabited a small hut at Mataveri where he watched the movements of the Inspector-General of Colonization for the Chilian Government for whom he showed the utmost contempt. In this hut he had stored his fishing net, clubs, gods, old iron, planks, hides, wool and perhaps, involuntarily, a formidable army of fleas.

Once upon a time the Kings of Easter Island, of which a lineage is preserved; were not allowed to be touched by a third person, being regarded as sacred. Moreover, their hair was never cut, a mark of royalty. It is related when the Peruvians kidnapped a large portion of the islanders, including the King, they left behind his only son, a boy of four, who, overcome with grief at being separated from his father, fell desperately ill. So critical had become his condition that a native woman who was nursing him in order to alleviate his sufferings wanted to cut off his long hair. The child protested in so earnest a manner not to be deprived of his emblem of royalty that the woman acceeded to his dying wish. This was the last of a race of kings which had governed Easter Island for some two hundred years. Decadence! The present king allows his hair to be cut—he has not much at any rate—he dives after lobsters in common with his subjects, and is the king of swimmers if nothing else. While on this matter we might mention that the Easter Islanders nowadays elect their chiefs annually; this event giving rise to a curious competition upon which depends the election of the Chief of Chiefs. It is the candidate which finds the first sea gull's egg

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of the season during which the election takes place who is chosen. Of course fraud is not absent. Another point, it has been alleged that in olden times the monarch abdicated on the marriage of his eldest son; this statement on good authority is inaccurate.

Apart from heavy clubs of toromiro, which they leave at home when no stranger is on the island and which they hide if otherwise, the Kanakas have no weapons and display fear in presence of firearms, but they have nevertheless a marked affection for other people's knives.

Earthenware is eagerly sought after; a basin, a pitcher, being given to the king he set his wife to break them up in small pieces, obviously to increase his acquisition by the quantity of potsherds.

Men and women go about in a semi-nude state, only married women wearing a pretence of a Polynesian breech-cloth made of "tapa" or "mahute." They are most anxious to obtain bright woolen shirts and stuffs, for what purpose, we ignore, as they never wore them. The Kanakas are not thieves, *á la Européene!* They take what they can lay their hands upon in so impudent, cool a manner and with so solemn a look, that all pretence to "lifting" on the sly is assuredly out of the question.

Whence come they? The Kanakas give two versions with regard to their origin and these traditions they readily admit are doubtful—a Kanaka never troubles himself to argue. The first is that the founders of their race came, many cycles back, in four ships with raised poops and prows, under the command of a king, Hato or Incuyo. The men were of mighty stature, and when they had landed put the head of a decapitated maiden at the prow of each vessel, which immediately plunged under the foam. The second tradition relates that thousands of generations back a migration took place from Oporo or Rapa-Ita, one of the Low Archipelago; hence they call their present abode Rapa-Nui or Great Rapa to distinguish it from Rapa-Iti or Little Rapa. Incuyo divided the island and women among his followers.

The question has been asked how came those three hundred or more statues, from five to fifty feet high, placed in position all over the island, or ridges, on the edge of overhanging cliffs, on stone-platforms, in the midst of altar groves, in recesses;

sometimes alone, or in groups from four to thirty? These monoliths are carved out of stone, some of trachyte lava, nearly all presenting the appearance of *torsos* terminating at the hip, sometimes with arms close to the side, now and again with hands sculptured in low bas-relief on the haunches. The head is flat, the top being cut off level to allow a "hat" to be put on. These "hats" are usually round and carved out of red tufa. In most cases these head-gears have rolled off and lie beside the giant monoliths as if the gods had cast them down in despair or rage at the decadence in their worship. The faces, generally speaking, are square, massive, disdainful in expression, the aspect always upwards, the lips thin, the upper lip short and the lower lip thrust up. The eye sockets are deep; in former days balls of obsidian were inserted; giving a terrible expression to the giants. At present, the eye sockets form a nest for birds. The nose is broad, the nostrils expanded, the ears with long pendent lobes. At Utuiti, the most curious features of the island presents itself in three stone platforms, crumbling away. On each side eight monoliths, some sixteen feet high and about seven feet over the shoulder, stood side by side. At present they are nearly all upset and broken. These mohias at Utuiti, described by Captain James Cook, are by no means the largest, for at Rana-Roraca, Hanga-Roa, Rana-Kao, Ponapav, Rana-Hana-Kana and Vai-Hoo, some measure not less than fifty feet and more. At Rana-Hana-Kana there are twenty-three made of hard rock and in a perfect state of preservation. At Hanga-Roa, the greater part are upset and children amuse themselves chipping off the noses, ears and inscriptions.

A few bear traces of carvings representing birds, axe-heads, paddles and occasionally, animals. Of these monoliths, but very few have found their way to the Old and New Worlds. One is to be found, I believe, at the Santiago Museum, Chili; one at the British Museum, London, brought over by a British man-'o-war and presented by the late Queen Victoria to the nation; another, brought over in 1870 by a French frigate, was found by Mr. Edwin S. Balch stowed away in a shed of the Paris Jardin des Plantes surrounded by a lot of old scrap iron and rubbish. Describing his "discovery," Mr. Balch says: "One of the most extraordinary works of art in Paris is the colossal head from Easter Island, now in the *Jardin des Plantes.* It is about

six feet in height, with a great, highly-modelled nose, deep cavernous eyes, a tiny slit of a mouth and a strong square chin. The ears are long, but not much worked out. There is scarcely any head back of the ears and a very low forehead. It almost seems as though the head was only intended to be looked at from the front. It is most dignified, neither childish nor savage, but decidedly advanced art. * * * "

Nowadays with all the engineering appliances at command it would be impossible to move many of these monoliths. There is absolutely no trace of metals on the island; there is no timber, no cordage; the island is more than two thousand miles distant from its nearest neighbor, Tahiti. It is impossible for these large masses of rock to have been broken off in such equal proportions and after having been carved, carried to their destination, for many of them weigh certainly more than two hundred tons.

Who were the sculptors whose work is surprisingly far from being rough or unskilled? Their work is as curious as the Idols and Temples of the Sun in Peru and Mexico and Guatemala, as the dolmens in Wales, the Pyramids, the giant temples of Luxor and Memphis, the towering gods of the Bhotan; more so, when we consider the geographical position of Easter Island. Another question arises, to what purpose, and by whom inhabited, were those stone caverns, in the shape of an inverted canoe, three feet high, three feet wide and from three to forty feet long? The most obvious agent in hollowing out caves, we know, is water, but these rock hollows, if not made by man, were formed, we are inclined to believe, by the passage of lava to the surface of the ground or by the imprisonment of steam and gases in the lava while it was in a molten state. Yet in spite of our doubts as to whether these caverns were or were not the work of a prehistoric race, we are forced to admit that our perplexity is great upon finding the entrances of these caverns guarded by a stone door. Inside there is no trace of their having been occupied, except a few scant inscriptions and figures and in some a sealed pavement which shows evident proof that this once served for some purpose, for when opened it revealed under the entire length of the passage numerous deep pits. In others, large quantities of univalve shells were found, and in one, a monolith differing from the others to such a de-

gree as to render it more interesting still. Roughly estimated, it weighed about fourteen tons and was eight feet high. In no instance has there been any trace found in these caverns of gold, silver, brass. They are empty.

Much attention is directed to the stone houses or huts, mostly fallen in ruins, made of stones laid one upon the other. These evidently are not so antique as the caverns.

Of wooden images or idols there are a few yet found, but they are jealously guarded by the old natives as relics of a past age. These idols in which the vertebrae and ribs are very pronounced, have strong semitic features and have none of the solemn repose of the colossal monoliths. The worship of wooden gods was much later than that of stone gods. Slabs of toromiro wood bearing hieroglyphs are likewise found and have been dwelt upon at length by the learned world. The wooden tablets are about fourteen inches long by five inches wide and one inch thick. One "specimen" is at the Santiago Museum, another at the British Museum, another in Paris. We pass over in silence the long stone passages, now in ruins, leading down to the sea. Were they the roads leading from a royal palace?

Some day perhaps Easter Island will hold a prominent position in the history of lost races. For it is here that the gigantic monoliths, curious hieroglyphs, caves, etc., offer a thread, binding the past with the present, a link all the more interesting when we consider its unique geographical position. During cycles of centuries the now extinct race must have advanced towards a high degree of civilization, not in the mind of the trader or missionary perhaps, but certainly of the artist when the latter contemplates the mohias which seem to point to a period when a powerful race lived on that island; then, perhaps, a continent, if no longer so in the times of Davis.

Tradition does not reach to that remote past; alone the monoliths are all that remain to bear evidence of a lost and mighty power of human labor, of art, of skill, of immense conception.

Naught have we learned of the prehistoric race. The natives also, who now inhabit Easter Island, are so little known that they are well worthy of the interest of the ethnologist. Their undoubted antiquity and ancient language, all combine to render them a peculiarly interesting race.

Once more the noble *"Tortuga"* stood on her course in the open sea.

SMELTING IRON ORES BY ELECTRICITY IN NEW YORK STATE.

Titaniferous iron ores, the geology of which has been studied by Prof. F. Kemp, of Columbia University, occur in the United States in "immense deposits," "in mountain masses" in the Adirondack region. They are "one of the most marvellous deposits in the United States." They are also found almost as abundantly in Minnesota, Michigan, Colorado, North Carolina, and most everywhere in the United States, and also in Canada, Sweden, Norway, New Zealand, Russia and other countries. In many districts, such as the Adirondacks, for instance, they could be mined for years in open quarry, constituting, as they do, the geological formation itself.

They are very rich in iron, containing 50 to 60 per cent. of metallic iron, are low in sulphur (0.025) and phosphorus (0.017), and also in silica (1 1-2 to 2 per cent.), with about 15 per cent. of titanic acid. Occurring in an igneous formation implies their being found in mountainous districts that are precisely in regions where it is possible to generate electric power for smelting purposes at a minimum cost. Lakes of 3 to 4 miles in length by 1 1-2 to 2 miles wide, with falls of about 60 feet from one to the other, are found, for instance, with a number of others of lesser dimensions, in the districts from which the writer has drawn much of the ores used in the manufacture of alloys. Charcoal can be had at a very low cost, limestone or other suitable fluxes are within easy reach, and the product, pig-iron, could follow a down grade to the tide water.

The writer has quoted this region with some details merely on account of its being familiar to him. But in many places in Canada and elsewhere similar ores occur also in abundance, being even available by means of water or other communication, and there, as in the Adirondacks, could be created locally an iron-smelting industry with conditions of economy particularly favorable.—A. J. Rossi, in *The Electrical Age* for June.

CALIFORNIA TURQUOISE IN FAVOR.

The turquoise mines of New Mexico and Arizona have lately not been as productive as formerly, says Mr. George F. Kunz in a report on the production of precious stones in 1905, which the United States Geological Survey will soon publish. The turquoise properties of California and Nevada have, however, been increasing their output. Considerable quantities of turquoise have been taken from the mines in the desert region of San Bernardino County, Cal. Many of the stones range from 50 to several hundred carats in size. Some of them have sold as high as $1,500 each. The color is pale, but it has gained favor, and large quantities of the stones have been sold in the form of beads for necklaces.

(Stated Meeting, held Wednesday, March 15th, 1905.)

Regulation of the Duration of Combustion.

By Byron Eldred, B. S.,

Member Am. Soc. Mech. Engineers, and Society of Arts, London.

The subject of my talk is an abstruse one at best, and I am going to start by disclaiming any intention of carrying you into the realms of theoretical chemistry or to burden you with charts and intricate mathematical calculations.

I am going to tell you about the conception of the idea for flame regulation and the development of this idea and its practical application to several arts.

The main object of my talk is to demonstrate the difference between the use of pre-generated heat and the use of a heat-producing agent or long flame which results in the generation of the heat where it is to be used. This may be quite properly classed as the regulation and control of the duration of combustion and of the temperature and volume of the flame.

The intensity of the combustion of fuel is directly dependent upon two factors—time and space. For example, the evolution of heat from a given amount of fuel in the shortest time and in the smallest space results in the hottest fire.

The subject of fuel combustion has been treated most narrowly because it has been customary to estimate the value of fuel from a thermal value standpoint; or in other words, heat was *heat* simply in all our calculations. Steam boiler practice has largely been to blame for this, owing to the ease of measuring results in that art.

I shall endeavor to make clear that conditions of combustion for steam generation are diametrically opposed to those experienced in the practice of almost any other art, and in de-

monstrating this, the fact will be brought out that the value of the fuel for use in other arts than steam generation is not properly to be calculated from the thermal value basis, as in steam generation.

The customary rating of fuels from a thermal value standpoint is, I believe, very largely responsibe for the very narrow view of the study of combustion afforded us in existing records. Combustion heat has been utilized for countless ages, and probably because of its commonplaceness combustion is not as well understood to-day as wireless telegraphy. The great importance of fuel for steam generation and the ease of measuring results in that art is also responsible for the very narrow view previously taken of fuel and fuel values for combustion. The steam boiler furnace is used essentially for the production of sensible heat, which sensible heat is applied to water and by convection evenly distributed over any desired area. The energy of the fuel employed for steam generation must be in the form of temperature energy or sensible heat, and at the same time be held in the smallest volume of gas carrier possible, consistent with the attainment of complete combustion. In steam-practice combustion we have the simplest and most limited chapter in the broad study of combustion. This chapter may properly be entitled the generation and application of pre-generated heat. This is the old, well-known chapter which has heretofore been generally accepted as the whole book. It is not my desire to repeat history, and I will simply bring out for the sake of comparison a few of the points.

The standards of fuel appraisement as established by calorimetric determinations, as aforesaid, measure only pre-generated or sensible heat. They are consequently misleading, narrow in scope and at the same time of little value in the other arts than steam generation, where combustion is most simply applied, that is, for the evolution of sensible heat.

There is much in the old axiom, familiar to us all in the form in which it has until recently been improperly stated, namely, that "Heat decreases in inverse proportion to the square of the distance from the seat of generation." This should be stated: "The power of a body to intercept heat is in inverse proportion to the square of the distance from the seat of generation."

A brief history of the conception of the Eldred Process may serve the purpose of making some points more clear. I wish especially to obviate the confusion which sometimes arises from the idea that the process is one for the conservation of waste heat; that the hot blast is the secret of its success, or that much combustible is returned and conserved from the escaping gases of the furnace operation.

As far as ten years back, I have noted and proved to my satisfaction in the study of combustion in connection with steam generation, that within reasonable limits a high furnace temperature produced a lower temperature of escaping gases than would a lower fire-box temperature. This I also determined by experiments to be due to the difference in volume of the gaseous heat-carrying body traversing the fire-box. A large amount of air in excess made a lower furnace temperature, and a large volume of gas carrier necessarily has to travel at such a rate to the stack that the water in the boiler would not have the same chance or opportunity to absorb the heat for useful evaporation that was afforded in the application of the same amount of heat in a small volume of gas carrier.

With this idea firmly fixed in my mind, I undertook, at the suggestion of a prominent lime manufacturing concern, to solve the problem of burning lime economically with coal fuel. My first attempt was to make what might be termed an economical fire for steam generating purposes—that is, a combustion of short duration. The conditions were ideal for such combustion; the furnace walls and the lime rock laying directly at the end of the furnace, absorbing the heat and reverberating this heat back on to the bed of fuel on the grate, causing a rapid destructive distillation. It was soon discovered that a high temperature was disastrous to lime burning, as the lime in the kiln was fused and cemented into almost a solid mass, and the disastrous effect of intense heat was plainly visible on the furnace walls. While the experimental kiln was being prepared for another demonstration, I observed the operating conditions of two similar kilns alongside. One was being operated with wood fuel, the other with a good grade of gas coal to which air was supplied by means of a steam blower. It was noted that one ton of this coal would afford a thermal value of 14,200 B. T. U. by testing in the Barrus Oxygen

Calorimeter, and that it would burn no more lime than a cord of wood under similar conditions, although the thermal value of the wood was slightly less than half that of the coal. Following up this clue in the endeavor to find the discrepancy apparent in the results obtained, the Eldred Process was conceived.

By analyzing the gases escaping from the two kilns it was quite evident that combustion was substantially complete. Neither was there any apparent difference in the temperature of these escaping gases, and the lime drawn from the kiln was also at the same temperature. To make the problem still more complex, it was found that the use of wood fuel would afford greater capacity than the coal fuel. From this it will be seen that the problem under consideration presented many difficulties, inasmuch as the results of actual practice did not bear out theory, that is, the theory based on results obtained in steam boiler practice. It became evident that the economical dissociation of the carbon dioxide from the lime rock was wholly dependent upon the proper application of heat at a certain temperature. I then demonstrated in the laboratory that 752° Fahr. were required to initiate the dissociation of carbon dioxide, and that in all probability 1200° Fahr. would suffice to completely transform a piece of lime rock of the actual size employed into calcium oxide or lime. The deduction from the experiment was that the heat derived from the combustion of the coal was practically all generated within the furnace before it came in contact with the rock within the kiln. By an electric pyrometer it was found that the furnace temperature was nearly 3,000° Fahr. Thus it became evident that the relatively small amount of lime produced with coal was due to the fact that the heat absorbing power of the rock and lime was such that the portions lying near to the furnaces took up and stored very much more heat than was required for calcination, to the detriment of the rock above in the kilns, thereby greatly reducing the efficiency of the coal fuel as compared with wood, it being further understood that the first body of rock subjected to heat of the furnaces would be maintained at the temperature of the furnaces.

To accomplish my purpose of making economically a good lime from coal, I set about to produce a flame with this fuel

which would resemble a wood flame in duration and heat intensity.

In the body of lime rock under treatment there was sufficient heat to maintain the original ignition of the gaseous fuel from the distillation of the bituminous coal employed, and my object was to apply this in form of a heat producing agent and complete its combustion in immediate contact with the rock undergoing calcination, producing heat over a large area, getting its full value and obviating the difficulties before experienced, or, in other words, carrying into practice the old rule that the quantity of heat intercepted by any two like bodies of rock is invervsely proportional to the squares of the distances from the seat of the generation of the heat.

The complete control of the regulation of the duration of combustion was accomplished by the use of neutral gases obtained from the kiln above the zone of combustion, to dilute the air supplied to the furnaces.

Instead of using the mechanical mixture of approximately 21% oxygen and 79% nitrogen ordinarily present in the atmosphere, I used enough diluent gas to give about the following proportions (An average of several analyses.):

Carbon dioxide	10.0%
Oxygen	14.6%
Nitrogen in air present	58.4%
Free nitrogen	17.0%

Owing to the fact that the oxygen in this gas mixture was much less in percentage amount than in the case of the normal atmosphere, the fuel body could be subjected to a strong forced draft which impelled the gases up into the kiln before combustion was completed, giving the desired result and at the same time allowing of the use of a forced draft under such conditions that the rate of combustion would be less rapid than with the ordinary natural draft and air. The presence of a larger volume of neutral gas carrier for the oxygen and the lower furnace temperature, presumably also decreased the rate of union of oxygen and combustible.

The CO_2 present in the draft supplied to the furnaces, also materially aided in the obtaining of the desired result by the splitting up of the gas as it passed through the fuel on the

grates, the heat absorbed by the endothermic reaction kept the furnaces down in temperature, lessening the rate of distillation to the desired degree.

Different fuels have been found especially applicable in different arts, but the scientific reasons for this fact seem to have been neglected to a remarkable degree by investigators. As illustrated in the limekiln experience before cited—the duration of the combustion of the fuel employed played the most important part in the obtaining of efficient results. Nature has provided numerous fuels which in combustion afford different velocities of combination or reaction, which means the duration of combustion, but she has supplied but one atmosphere to support combustion. The Eldred Process regulates the velocity of combination of the oxygen of the air with carbon by creating an artificial atmosphere low in oxygen, making it possible to use a strong forced draft and to utilize its mechanical force as a flame impeller. By proportioning the amount of diluent we may delay velocity of reaction to any desired degree, applying fuel value in the form of potential heat with the ultimate development of the sensible heat where it is to be used.

The comparative results of my first test will attest the value of the invention. The average coal consumed per barrel of lime on an output covering a year's run was shown to have been 73.4 pounds. The appreciation and application of these new principles during a week's continuous test showed an average coal consumption per barrel of 33.46 pounds.

A very good homely illustration of the economical results obtained by the application of the heating agent for the generation of heat where it is to be used, is found in the human body; where we know carbon is widely distributed and the oxygen carried in the blood to this carbon, the heat being generated over and throughout the entire body, the most wonderfully economic production of heat resulting in the operation. Consider what it would mean if the animal body had to be kept warm by the application of pre-generated heat applied to a hand or foot.

My process has been successfully applied to many branches of arts where comparatively low temperatures were required. The roasting of refractory ore mined in the Cripple Creek dis-

trict, showed better and more efficient work performed with 43% less coal of the same grade and from the same mine than was previously employed under forced draft conditions.

The Eldred Process involves a cyclic return of a portion of the waste gases, and this has led to speculation as to the effect such a cycle of travel has upon the constitution of the escaping gases. It has been thought by some that the use of diluent

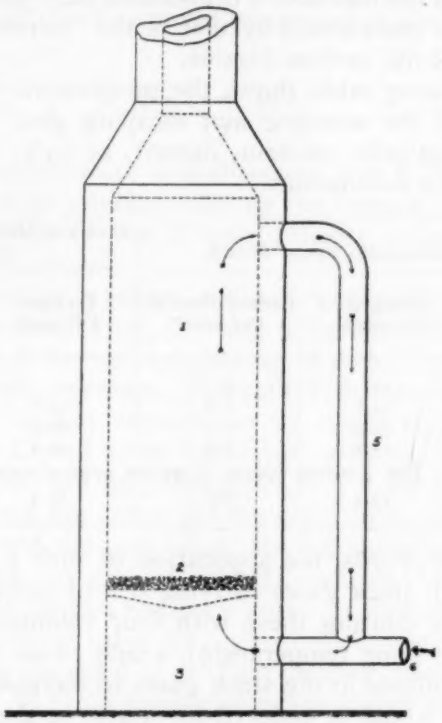

FIG. 1 GAS CYCLE

gas would increase the sensible heat losses at the stack. This is not the case. To illustrate the question involved in the so-called "gas-cycle," reference is made to Fig. 1. In this diagram 1 represents a chamber containing the material to be heated. A determined portion of the products of combustion is drawn out at the base of the stack and carried back uncooled through 5, to ashpit 3. A measured amount of air is admitted at 6. The gas and air mingle and pass through the grate and

fire-box 2. At the start the burned gases coming from the carbon fuel and passing up the stack normally contain nitrogen, 79%, oxygen, 15% and carbon dioxide, 6%. Suppose one part of these "normal" gases to be drawn back at the stack and to mix with four parts of air from 6, then the gas entering 3 will contain oxygen, 19.7% and carbon dioxide, 1.2%, the nitrogen, of course, remaining substantially unchanged. These pass through the fuel and, it is assumed, burn the same amount of carbon as represented by that in the "normal" gas, or the equivalent of 6% carbon dioxide.

The following table shows the progressive changes in the character of the entering and escaping gas. The nitrogen remains practically constant, namely, at 79%, so it need not enter into the calculations.

	Gas Discharged from Stack.		Gas-air Mixture Entering Ash-pit	
Interval of time.	Oxygen. Per cent.	Carbon dioxide. Per cent.	Oxygen. Per cent	Carbon dioxide. Per cent.
0	15	6		
1	13.7	7.2	19.7	1.2
2	13.5	7.4	19.5	1.4
3	13.4	7.5	19.4	1.5
	The limiting values therefore approximate.			
	13.4	7.5	19.4	1.5

Or, in other words, the application of such a cyclic process, starting with stack gases carrying 6% of carbon dioxide and continuously diluting these with four volumes of air (calculated at the same temperature), would cause the percentage of carbon dioxide in the stack gases to increase to 7.5%, and the oxygen would be reduced to 13.4%, or the excess air expressed in percentage of that chemically combined would be reduced from about 250% to approximately 180% excess, a difference of 70%. In many furnaces of the reverbatory type 75% of the heat generated is carried away in escaping gases. Therefore, the reduction in the excess air by 70% would be equivalent to an increase in fuel efficiency of about 20%.

According to the theory of limits, equilibrium in this system is never attained, but actually it is quickly reached so far as can be shown by analysis of the gases at different points.

In calculating the gas-air mixture required per pound of coal, one has to take into consideration two factors. First, that less oxygen by volume is present than in ordinary air, and, secondly, that less excess oxygen actually is required with the Eldred Process. A slow, drawn-out combustion seems to require less oxygen for its completion than a rapid combustion.

The following formula serves for calculations. The cubic feet or gas-air mixture A required per pound of coal, allowing no excess is:

$$A = \frac{32\ (T + 440)}{5\theta}$$

where T is the temperature in Fahrenheit and θ the oxygen content of the gas-air mixture entering the furnace.

In the application of the Eldred Process various forms of apparatus are employed.

A form of apparatus is shown in Fig. 2, as applied to a lime-kiln of the conventional type; G being a furnace communicating with a cupola A through an opening or arch. J and K are the fire and ash-pit openings, provided with suitable doors. A draft pipe or conduit connects at its upper end with A, through opening C, and at its lower end with the ash-pit B, through opening E, and has interposed in it a fan-blower D. That part of the conduit above the fan constitutes the suction pipe of said fan, and the part below the fan constitutes a delivery pipe therefor. A gate or valve H controls this delivery pipe. The fan has also an auxiliary outlet or delivery pipe I, controlled by a gate or valve through which a portion of the kiln gases may be disposed of without causing them to pass through the fire. At F the suction pipe is provided with an air inlet, also controlled by a valve. By adjusting this valve the relative proportion of air and kiln gases in the draft may be exactly controlled.

In conclusion, I may say that the ease of measuring the evaporation of water per unit of fuel or combustible employed, has distracted scientists from a full realization and clear understanding of what every practical furnace man employed in arts not dependent on evaporation of liquid masses fully appreciates—that it is erroneous to measure fuels by mere capacity to raise the temperature of water. There are almost countless

other applications of heat energy where no convection current exists to convey and equalize the energy imparted. Peculiar and hitherto unnoticed or at least uninvestigated discrepancies exist in the efficiency of different fuels for the same work under identical conditions. For example, I find as before stated, that one ton of coal used in an externally fired limekiln will do only about as much work as a cord of wood, yet the coal is of

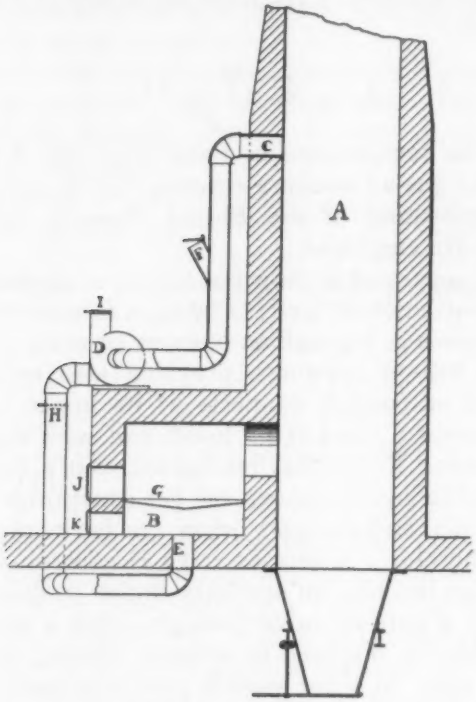

Fig. 2.

twice the theoretical thermal value. The lime burner can produce superior lime using wood fuel.. He says: "Wood is the natural fuel for burning lime." Why? "Because it makes a flame of better quality than any other fuel commercially obtainable." The brick burner will tell the same story. The metallurgist wants a different quality of flame for varied branches of his art. Science has paid little or no attention to this intricate question heretofore. Nature's storehouse has

provided fuels of different flaming qualities, but unfortunately, her supplies are not replenished as rapidly as they are withdrawn, and wood, where needed most, has been exhausted and science has been striving for a remedy.

In the study of fuel natures and combustion we have many things to reason with that have been neglected heretofore. Time and space or duration and volume of chemical action must be most prominently reasoned with in combustion studies. Properly reckoned, fuel values must take into account—capacity of combustion obtained from union with oxygen, more especially with reference to duration or rapidity of union. The more rapid the union of oxygen with the combustible the more intense the heat evolved. I have classed this as the duration of combustion, and on the duration of combustion afforded by a fuel depends the adaptability for special work, and each bit of combustion work has a duration point of maximum efficiency. The heat evolved in a given time in a given space depends upon the duration of combustion afforded. In other words, from incomplete investigations made with somewhat crude apparatus, I have concluded that efficiency in combustion is dependent on heat wave lengths synchronous with the wave lengths of the material under treatment, and the heat wave length may be consistently regarded as directly dependent upon the duration of the combustion of the fuel used. Furthermore, I believe that we are too inclined to designate flames broadly under the heads of reducing oxidizing and neutral. The chemical effects of these flames are not realized to any great extent in a great many instances where they are respectively employed, and almost unconsciously flame regulation has heretofore been crudely practiced by regulating blast conditions and building light or heavy fires, as the case might demand, oxidizing or reducing flames. As an example of this, coal fired sheet-mill furnaces throughout the country employ heavy beds of fuel under forced draft for the purpose of pushing a long flame into the furnaces. Thus the flame length or duration of the combustion is maintained at the expense of the fuel.

We are inclined to explain problems too often by chemical theorizing. This problem presents a side which allows of a most simple and beautiful explanation. The explanation can

be found in the study of the difference between the indirect application of pre-generated heat to a solid body or fragmental mass and the direct application of a heat generating or producing agent to such a body or mass. There is so much food for thought and such wonderful results obtainable from the study of apparently so simple a subject, that one marvels that it has been heretofore totally neglected.

THE SEARCH FOR DIAMONDS.

Never before in the history of the United States has there been such a demand for diamonds as there was in 1905. Large quantities were imported, but the country produced none. In 1903 it produced diamonds to the value of $50, in 1901 it had an output worth $100, in 1900 its production was valued at $150, and in 1899 the country boasted native diamonds to the value of $300. Diamonds have been discovered in the United States in four different regions, but their actual place of origin is in every case unknown. All have been found in loose and superficial deposits, and all accidentally. It is not at all improbable, however, that some day the original sources of this queen of gems may be discovered.

The high price of diamonds has made the recent search for these precious stones in the United States and Canada keener than ever before. A careful watch for diamonds was kept during the examination by the United States Geological Survey of many samples of gold and platinum sands at the Lewis and Clark Exposition in Portland, Ore. A lookout for diamonds has also been kept by a number of persons who have been dredging for gold on an extensive scale in the rivers of California. In neither case have any finds been reported.

The occurrence of diamonds in the United States has been treated in some detail by Mr. George F. Kunz in a report which the Geological Survey will soon publish.

TOURMALINE AND TOPAZ IN SOUTHERN CALIFORNIA.

The southern counties of California bid fair to rival the Ural Mountains in the production of tourmaline, beryl, topaz, and the other precious stones which have been the pride of that region for the last half century. The Palo region in San Diego County has become especially notable in gem production, and Mr. George F. Kunz, of the United States Geological Survey, calls attention in his forthcoming report on the production of precious stones in 1905 to the fact that a number of adjacent localities give indication of yielding the same minerals.

Section of Physics and Chemistry.

Analytical Notes.

By Samuel S. Sadtler.

DETERMINATION OF THE HEAT OF COMBUSTION OF SOME COAL BY THE PARR COLORIMETER.

In Parr's original article, which appeared in the Journal of the American Chemical Society, October, 1900, results of determinations made on Illinois coal were given, and comparisons made with the Mahler Bomb Calorimeter. In this article, the only charging material, with the exception of coal, is peroxide of sodium. Later with Lunge, it was stated that with hard coals (anthracite) a mixture of persulphate of ammonia and citric acid in definite amount, the heat contribution of which was found by a blank experiment, could be used to completely burn the carbon which would otherwise escape combustion with peroxide alone.

The writer believes that a better method of procedure, which does away with the blank determination, is to make the combustion with nothing but the coal and peroxide, and then to dissolve the product of the combustion reaction in a casserole with water, acidify with commercial muriatic acid and filter through a Gooch crucible prepared with an asbestos filtering layer. The piece of No. 10 wire used to start the reaction being picked out before filtering. If there is any heavy residue in the casserole, wash it several times with water and then with nitric acid (about 1-5) to dissolve any small particles of metal or oxide. The crucible is then dried to constant weight in an oven at 110°C., ignited and re-weighed. The difference is carbon. Multiply the weight found in grams by 2 (if half-

gram charge of coal was used) and then by 14,400 to convert into B. T. U. Add this result to that found in the calorimeter. Results will agree to about 50 B. T. U. if care is followed in the measurements of temperatures.

The writer feels that no matter how carefully the combustion is carried out, reliance in the results should not be had until the absence of a carbon residue was ascertained. The additional step of filtering and weighing up the residue is simpler and more certain than with the use of an exciting charge.

Successful results have not only been obtained with a wide range of coals, but the heat of combustion of samples of tar (water free), peat, and powdered cacao shells have been obtained. With crude oils, the writer has not been successful, due to the more volatile constituents rising to and condensing in the top of the combustion chamber, and thus escaping combustion.

SULPHUR IN OILS BY THE SAUER-MABERY METHOD.

The improved method here suggested is so simple, that it seems probable that a citation to the same effect might be found somewheres in the literature, but the writer has not seen such.

In the method described by Mabery, the air or oxygen is carried by a small tube within the main combustion tube to a constriction which is strongly heated, and at this point it meets the current of oil vapor mixed with a little air that is used to slowly drive it to this point, the oil being in a small boat under the air (oxygen) inlet tube and about half way from the ends of the tube to the constriction.

The improvement to be described, consists in only slightly drawing out the combustion tube at the center and putting a plug of platinized asbestos in this narrower portion. Instead of the oil vapor flashing through the tube, it burns quietly in the "contact" substance and the reaction can be readily watched at this point, as the vaporization and driving forward of the oil can be so regulated as to give a nearly steady glow. This must neither extend all the way to the other side of the plug, nor, until the reaction is practically over, fail to glow.

The writer has obtained quite satisfactory results on sulphur

oils, with this method, but prefers to use the special crucible described by him in the Jour. Amer. Chem. Soc., September, 1905, as he has found it useful for all sulphur-containing oils he had tried. The modified Mabery method is described, however, for the benefit of those who have only the facilities for carrying out the work by this method, and not by the "Inner Crucible" method.

USE OF MODIFIED COCHRAN FLASKS.

The flasks described by Cochran are for determining the percentage of fat in milk and milk foods, and are used similarly to the flasks or bottles used in the Babcock method. By heating, use of sulphuric acid and ether, the fat is collected without the use of a centrifuge. The writer had flasks* made, with the neck graduated with 100 divisions of larger bore, so that gas bubbles could rise to the top, and water and oil layers could separate.

This flask was designed for some other application than those suggested by Cochran, namely:

(1). The determination by volume of the non-saponifiable oil, in lubricating and similar oils.

(2). The approximate determination of naptha in turpentine.

(3). The determination of the water in substances themselves soluble in heavy solcents, such as $CHCl_3$, CCl_3 and CS_2.

In the first of these cases, a considerable number of tests were made which were for the most part unfavorable, in that it did not seem to be even approximately accurate for some mixtures of mineral and animal oils, such as neatsfoot and lard oils, which seem to form the most troublesome emulsions. It may be possible to overcome the difficulty with the emulsions, and to get practically all the oil to rise in the graduated tube, but it is likely to be at such effort as to rob the method of any advantage as to quickness of operation. With some other oils, useful approximate results may be obtained.

The other two uses, which may be of only limited application, were successful.

The separation of naphtha may be carried out substantially

*Arthur R. Thomas & Co., Philadelphia, Pa.

as given in the U. S. Pharmacopœia, f. 236, described as follows:

"If 5 cc. of oil of turpentine be placed in a small beaker, and 20 cc. of sulphuric acid be gradually added, with agitation, while the beaker is cooled by immersion in cold water, and the contents, after cooling and renewed agitation, be transferred to a burette, graduated in tenths, the clear layer which forms after the dark mass has settled should not measure more than 0.35 cc. (absence of petroleum, benzin, kerosene, or similar hydrocarbons)."

After thorough cleaning with chromic and sulphuric acids, the flasks are filled with water, and then the oil under investigation is slowly dropped on the top of the small tube, the displaced water overflowing at the top of the larger tube. To counteract the lightness of the turpentine, the flask is tipped so that the position of the small graduated tube is raised compared with the larger tube. When the lower turpentine layer is brought down to zero and the upper layer is at or near to 100. A short length of rubber tubing, with a pinch cock, is then put on the larger tube and then the flask tilted until the layer of turpentine is brought down to the rubber. The flask is then righted. It still contains a little water, but when the mixing chamber is half filled with sulphuric acid, the water does not interfere with polymerizing of the sulphuric acid on the turpentine. The flask is cooled while the sulphuric acid is poured in, and while shaking, if much heat is developed. The acid is poured down the sides of the large tube in such a way that any little oil adhering to the sides is washed down. The flask is then filled with sulphuric acid until the mixture is brought just to the lower end of the graduated tube. After standing about an hour, the sulphuric acid is added to the larger tube, until the naptha layers are both within the scale. The difference in the readings gives the approximate percentage of naptha, by volume.

FOR THE DETERMINATION OF WATER IN SUBSTANCES SUCH AS CAMPHOR.

For this determination the flask must be standardized. This may be effected by first filling with a heavy organic solvent

such as carbon disulphide or carbon tetrachloride. Then by carefully tipping the flask to depress the level of the solvent, water is dropped upon the surface of the solvent in the graduated tube. Six or eight drops will be sufficient for accurate reading in the tube, indeed, the accuracy of the standardization will be guaged by one's ability to measure the water that is run in. Weighing would be more accurate than the use of the burette.

The flasks made for the writer had a graduated tube of about 7/64 inch inside diameter and with 100 divisions in a little over 3½ inches. Each division is about 1/220 c.c., or 100 divisions equal .45 c.c.

With a flask of this size, about 1.5 grams of crushed well-sampled camphor is used. If the sample contains 2% of water, the reading will be 4.4 or 44 divisions. If .4554 gram were taken, each ten divisions would correspond to 1% of water.

The weighed sample is introduced into the large tube, and washed down with a little light solvent, such as gasoline. The dirt then settles and then the flask is filled up with carbon tetrachloride, so that the water can rise in the small tube and be easily read off.

The writer offers the foregoing reference to the flasks, more in the light of suggestions than exact contributions to the literature. He believes, however, that workers will find that these and other uses for them will warrant their gradual introduction.

THE WORLD'S FAMOUS DIAMONDS.

The following list gives the weight of the world's most famous diamonds: Kohinoor, after second cutting, 106 carats; Loterie d'Angleterre, 49 carats; Nizam of Hyderabad, 279 carats; Orloff, 194 carats; Kohinoor, after first cutting, 279 carats; Regent of Pitt, 137 carats; Duke of Tuscany, 133 carats; Star of the South, 124 carats; Pole Star, 40 carats; Tiffany, yellow, 125 carats; Hope, blue, 44 carats; Sancy, 53 carats; Empress Eugenie, 51 carats; Shah, 86 carats; Nassak, 79 carats; Pascha of Egypt, 40 carats; Cullinan, 3025 carats; Excelsior Jagersfontein, 969 carats.

MME. CURIE has been nominated by the council of the University of Paris to succeed her husband, the late Prof. Curie, in the chair of General Physics held by him at the time of his death. The nomination has been accepted by the Minister of Public Instruction.

VANADIUM STEEL.

Willans & Robinson are now producing special vanadium steel alloys at the rate of 800 tons per annum at their Queensferry works, England. The ferro-vanadium used for the manufacture of these special alloys is obtained from the Llanelly works of the New Vanadium Alloys Company, in South Wales, and contains up to 30 per cent. of vanadium. The chrome-vanadium steels show the most remarkable properties. These contain from 10 to 20 per cent. vanadium. The vanadium steel industry is altogether an English industry; 80 per cent. of the production is taken by the motor car and motor omnibus manufacturers. In one case 150 axles of chrome-vanadium steel were ordered and are now running with satisfactory results, and a repeat order for 400 axles of the same alloy has been given. Chrome-vanadium steel has also been exported to France, although an import duty of £5 per ton has to be paid upon it.

The effect of vanadium upon ternary and quaternary steels is to increase the resistance to both static and dynamic tests. The highest test yet obtained from a chrome-vanadium steel, after special heat treatment, was a maximum breaking strain test of 193 tons per square inch; this steel showing at the same time great resistance to dynamic and torsional tests. This is a combination of properties which has never been obtained before, and is the peculiar feature of the chrome-vanadium steels. The nickel-vanadium steels are of great strength, but show much lower resistance to dynamic and torsional tests.—*Eng. and Mining Jour.*

TECHNICAL NOTES.

Care should be observed in placing direct-current motors where there is risk of gas; for the explosive may be ignited by spark or heat.

Not only does moisture in coal cause it to crumble on exposure to the air, but each per cent. of moisture present means 20 lbs. less fuel for each ton of coal. A coal that runs high in moisture, will usually break or crumble on exposure to air; this slacking being due to a loss of moisture from the composition of the coal.

The safest cable to use for direct-current work in the mines, is the concentric cable with double galvanized iron wire armoring, and for three-phase machines, the three-core cable with similar protection. Experience and careful observation have shown that the wear on a rope increases with the speed. It is therefore better, if more work is to be done, to increase the load and run at the same speed, than to carry the same load at a greater speed.

In the conveyance of compressed air, it should be remembered that the efficiency is diminished practically as the diameter of the pipes is decreased, which means, of course, that the pipes should be as large as conveniently practicable, with commodious receivers adjoining the air compressors.

The fixed carbon of a coal will not evaporate as much water as an equal weight of volatile combustible matter when properly fired; however, in practice, so much of the latter is lost that in determining the steam value of a coal, we may assume the carbon to be the only useful constituent.—*Eng. and Min. Jour.*

(Stated Meeting, held Thursday, March 29th, 1906.)

Fluorescence and Phosphorescence.

By Edward L. Nichols.

The wierd shining in the dark of certain bodies; the gleam of sea water when disturbed and other allied phenomena must have been known from the earliest times. When phosphorus was discovered, in the 17th century, the property which it possesses of glowing with a greenish light attracted universal wonder, and from that time the name of phosphorescence was given to all cases of the emission of light by bodies at ordinary temperatures.

At first it was imagined that the presence of phosphorus was indicated wherever phosphorescence occurred or perhaps that there was a group of allied bodies to which the phenomenon was ascribed. When, for example, in 1676, Picard noticed that upon shaking the mercury in a barometer in the dark there was a glow from the vacuum in the top of the tube he assigned it to the presence of a mercurial phosphorus. Hauksbee, one of the best known electricians of that period, studied this phenomena at considerable length, and he showed himself a true forerunner of the electricians of our day, who would have us believe that all physics is but a branch of electricity, by assigning to the phosphorescence of the barometer tube an electrical origin.

There are two distinct kinds of phosphorescence, the phosphorescence of vital organisms; of glow worms, fire flies, jelly fish and the animalculæ that cause sea water to shine at night, and the phosphorescence of matter not imbued with life. The presence of light always indicates radiation and radiation is a process involving the expenditure of energy. In the case of living organisms the energy thus expended may have its origin

in the vital processes since an animal is a machine consuming fuel and transforming the energy thus obtained into various forms. In other cases radiation is due to motions of the particles of a body derived from energy received from without or to setting free of energy stored when the body was formed. The usual type of visible radiation, known as *incandescence*, is common to all bodies when heated above a certain temperature, the red heat. It is a definite function of the temperature and is produced by one stimulus only,—heat, which sets up the necessary motions of the particles. The emission of luminous radiation due to any other stimulus is termed *luminescence*. It may occur at any temperature; has been observed even in the case of bodies cooled by liquid air*, and is known to accompany the incandescence of certain oxides, modifying the light of freshly ignited CaO, ZnO, etc.† It is variously known, according to the stimulus which produces it, as:—

Photo-luminescence, produced by the action of light.

Tribo-luminescence, produced by friction.

Piezo-luminescence, produced by pressure.

Crystallo-luminescence, produced by the process of crystallization.

Chemi-luminescence, produced by chemical action.

Electro-luminescence, produced by electrical action.

Cathodo-luminescence, produced by the action of cathode rays.

Radio-luminescence, produced by the action of obscure rays from the radio-active elements.

X-ray-luminescence, produced by the action of Roentgen rays.

Thermo-luminescence, produced by sudden changes of temperature.

Luminescence of a body observed during the time that the stimulus acts is called *fluorescence*. When the emission of light continues after the stimulus has ceased the phenomenon is called *phosphorescence*.

Why in many cases the luminescence of a substance ceases with the excitation or so soon thereafter as to be observable

*See Dewar: Proc. Royal Soc. (5) p. 340.

†Nichols and Snow: Phil. Mag. (5) Vol. XXXIII, p. 19.

only by means of the phosphoroscope while in other instances the effect may last for minutes, hours, or even months is not as yet definitely known. Liquids are fluorescent but never phosphorescent and the fluorescence of liquids is believed to be dependent upon the dissociation of a dissolved substance. It has indeed been shown by Buckingham* that the fluorescence of electrolytes increases in a definite manner with the dissociation.

In solids luminescence is supposed to occur only where the constitution is that of a solid solution and to be due to the presence in solution of traces of certain elements, such as copper, chromium, manganese, nickel, cobalt, lead and certain of the rare metals, such as cerium, lanthanum, yttrium, erbium, etc. The solvent may be a sulphide, such as CaS, which is used in the preparation of Balmain's paint, or ZnS, as in Sidot blende; a fluoride, such as CaF_2, or fluorspar (from the luminescence of certain specimens of which as studied by Stokes the name fluorescence is derived); a silicate, as in willemite, etc.

The difference in the behavior of specimens of the same substance as regards the duration of the effect is very striking. One of two specimens of willemite, for example, the fluorescence of which when excited by the light from a spark-gap with iron terminals exhibit the same brilliant green color will continue to glow for many minutes after the cessation of the stimulus while the light from the other disappears at once.

The character of the spectrum of luminescent substances differs from that of an incandescent body in several important respects. Both classes of spectra are continuous, but the range of the wave lengths represented in incandescence is far greater than in luminescence. In the case of incandescence the maximum of intensity, for any temperature which can be artificially produced, lies in the infra-red and the position of the maximum moves progressively from longer to shorter wave lengths through the spectrum in accordance with a definite law as the temperature rises.

In the case of luminescent bodies the maximum of intensity, so far as known, is always within the visible spectrum or in a few instances, possibly, in the ultra-violet, and its position is

*Buckingham: Zeitschrift für Physikalische Chemie, Vol. 14, p. 129.

fixed as to wave length for a given substance and *independent of the intensity of excitation and of the character of the stimulus.**

Fig. 1 affords a comparison between the energy curve of the spectrum of incandescent carbon at 1600° C. and that of the luminescence of fluorescein. In the former only the small part of the energy which is represented by the area enclosed by that portion of the curve which lies between the limits of the visible spectrum, V and R, is light-producing, whereas the entire spectrum of luminescence is comprised within those limits. The maximum of the incandescence spectrum is situated at about 1.47 μ, that of the luminescent spectrum at 0.52. μ Drawn in this way the curve for luminescence appears to indi-

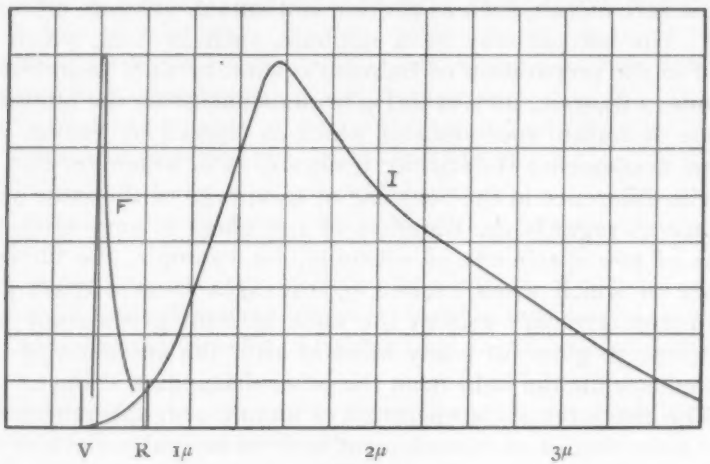

Fig. 1

cate a narrow band, almost a line; but if we increase the scale of wave lengths twenty-fold, as in Fig. 2, we find the type of the luminescence curve to be very similar to the energy curve for incandescence. Each is characterized by a single sharply defined maximum and by a steeper slope towards the violet than on the side towards the longer wave-lengths.

This resemblance is by no means confined to this particular case. The curves for the following substances are of the same type† and it is probably common to all luminescence spectra of solids and liquids.

*Nichols and Merritt: Physical Review, Vol. XIX, p. 18.

†Nichols and Merritt: Physical Review, Vol. XVIII, p. 403; XIX, p. 18; XXI, p. 247.

FLUORESCENCE SPECTRA.

Fluorescein (in alcohol).
Eosin "
Naphthalin-roth "
Rhodamin "
Resorcin-blau "
Quinine Sulphate (in water).
Chlorophyll (in alcohol).
Aesculin (in water).
Canary Glass.
Sidot blende.

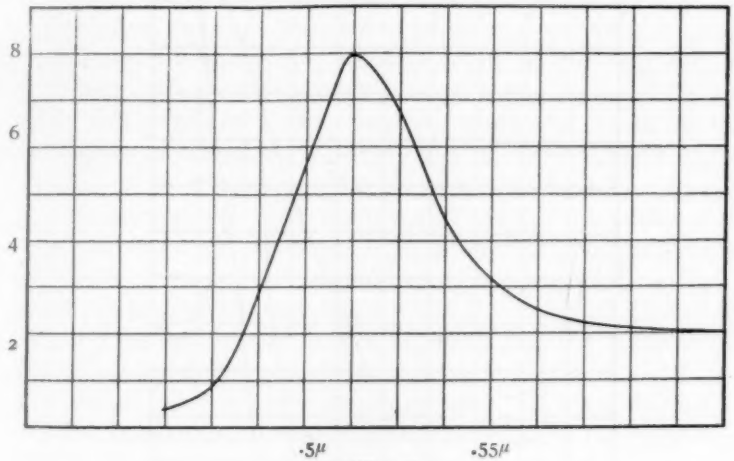

Fig. 2

PHOSPHORESCENCE SPECTRA.

Cuban fire fly (measured by Langley).*

Numerous inorganic phosphorescent substances studied by Lenard and Klatt.†

The intensity of luminescence is always far too small to admit of the determination of the distrubution of energy in the spectrum by direct measurement, but it is possible by means of the spectro-photometer to compare many such spectra with the spectrum of such source as the acteylene flame, the energy curve

*Langley and Very: Phil. Magazine (5) XXX, p. 200.
†Lenard and Klatt: Drude's Annalen (15) pp. 225, 425, 633.

of which is known, and thus to be obtained the curve for the distribution of energy in the spectrum of the luminescent body. It is in this indirect way that the curves shown in Figs. 1 and 2 were determined. By using monochromatic light of various wave lengths for excitation we find that rays corresponding in wave length to the regions of absorption of the substance act as a stimulus whenever the wave leungth of the absorption band is less than that of the luminescent spectrum, and that absorbed light of greater wave lengths is inactive.

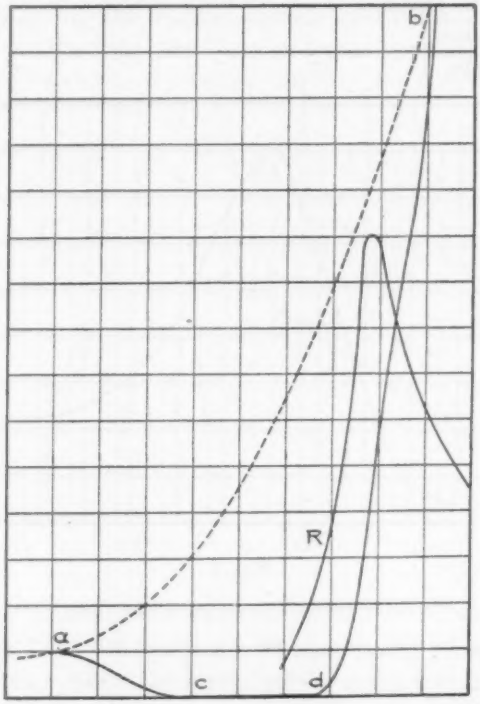

Fig. 3

The position of the spectrum of luminescence is determined by that of some absorption band nearly or not coincident with the luminescence spectrum, the maximum of the absorption band always lying slightly further towards the violet.

In Fig. 3, for example, the dotted line *ab*, is the energy curve of that part of the spectrum of an acetylene flame which

is included in the diagram. If a cell containing a certain solution of rhodamin be interposed in the path of the light from the flame we get the energy curve, *acdb*, for the transmitted light. In other words, the solution, which is nearly transparent at *a* and at *b* becomes nearly opaque from *c* to *d* and the figure depicts an absorption band of this solution having a maximum (or minimum transmission) between *c* and *d*. Associated with this band is the fluorescence spectrum of rhodamin, the energy curve of which is shown (curve R). The maximum of fluorescence lies at 0.577 μ towards the red from the maximum of absorption.

In all the cases studied the absorption band and the luminescence spectrum overlap and all the wave lengths included in the absorption band are capable of producing ecitation. Since the luminescence spectrum is independent of the character of the exciting light, the longest waves that may be used for excitation will produce a fluorescence spectrum, some of the wave lengths of which are shorter than the wave length of the light used as a stimulus. The law of Stokes, who thought from his observations upon fluorite and some other substances, that the exciting light never exceeded in wave length the fluorescence which it was capable of producing, is not strictly true.

Many of the phenomena observed in the study of phospherescence would lead one at first to suppose that the relation between phosphorescence and fluorescence could not be the simple one stated in a previous paragraph. In many instances the color of phosphorescence is seen to change as the light dies away. In other cases the fluorescence of a substance will present one color, and the phosphorescence, another. When, for example, Sidot blende is excited by means of ultraviolet light or by the ex-rays it exhibits a fine blue fluorescence which upon cessation of excitation changes to a green phosphorescence.* These phenomena are, however, capable of explanation from the fact established by Lenard and Klatt† and others that many substances have luminescence spectra containing two or more bands. It is probable that each band in such luminescence spectra is due to the presence in solution of a

*Nichols and Merritt: Physical Review, Vol. XXI, p. 247.

†Lenard and Klatt: l. c.

given metal. Where only one metal is dissolved we have a fluorescence spectrum consisting of a single band. Where two or more metals are present each one may produce independently its own band giving a complex spectrum.

The rate of decadence of these bands, after excitation ceases, varies greatly and the color of phosphorescence therefore changes as the light dies away. In certain cases decay is so rapid that it is not possible to observe a color which is prominent in the fluorescence of the substance for any appreciable time after excitation has been interrupted. Since moreover each band is associated with a particular absorption band the fluorescence may vary greatly with the stimulus. In Sidot blende, the fluorescence spectrum of which consists of a brilliant green band and of one or more bands in the violet, we may produce a green fluorescence by the use of light in which the visible rays predominate, or blue fluorescence, by means of an ultraviolet stimulus or by the use of X-rays. Such stimuli excite the violet bands so powerfully that they dominate in the production of the color or fluorescence, but as soon as excitation ceases the violet component disappears, on account of its exceedingly rapid decadence, and the phosphorescent light, which persists, is green in color. The varying rate of decay of two bands may likewise serve to explain the change of color of phosphorescence as the effect dies away. The more fleeting of two bands may be the stronger, immediately after the cessation of excitation but its domination over the color-tone of the light disappears with its decadence and the color goes over by insensible gradations to that characteristic of the other band, which although weak at first is more persistent.

There is another cause for apparent changes of color which affects all phosphorescence,—the transition to the faint gray which follows any color sensation whatever as the intensity becomes too feeble to stimulate color vision. The rods of the retina according to the physiologists continue to be excited by these weaker rays and this sensation, which is independent of the wave length of the stimulus, is ill-defined colorless gray sometimes designated by the term *rod white*. This is the final retinal sensation received from the light of phosphorescence before extinction.

The law of the decadence with the time was carefully in-

vestigated by E. Becquerel, to whom our first systematic studies of phosphorescence are due. Becquerel found his observations to be approximately expressed by the exponential equation

$$I = I_0 e^{a t}$$

but subsequent measurements have shown that the decadence does not follow this simple law and several attempts have been made to find an empirical equation which will represent the observed results. It is evident that in the case of substances having several bands in the phosphorescence spectrum, each of which differs in its ray of decay, the law of decadence for the light as a whole will be a complicated one. Since, however, as has been shown, by Professor Merritt and the present writer*, the various wave lengths of a single band decay at the same rate, it should be possible from observations upon the light of such a band to determine the law.

The phosphorescence of Sidot blende affords favorable conditions for the study of these phenomena since the violet bands are of very short duration while the brilliant phosphorescence of the green band is persistent. In some recent experiments on this substance it was found possible to observe a given wave length of the green phosphorescence band by means of the spectrophotometer and to record its intensity as a function of the time. The observations covered an interval of about twenty seconds from the cessation of excitation.

A study of the curves thus obtained showed that the decay of intensity was not exponential. If, however, we adopt the theory that the exciting light serves to dissociate the molecules of the luminescent substance, breaking them up into two electrically charged particles, and that luminescence is due to the recombination of these separated ions; and if we assume that the law of recombination is the same as that for ions in a gas; it is possible to derive an expression for the intensity of the light due to the collisions between the positive and negative ions. If the number of positive ions present in a unit of volume at any time be t and the number of collisions between a position and a negative particle be proportional to the number

*Nichols and Merritt.

of each present; and if, finally, a certain proportion of the collisions produce a recombination of the ions with emission of light; we have

$$I = \frac{1}{(a + bt)^2}$$

where a and b are constants. The intensity I according to this hypothesis should be inversely proportional to the square of the time and a curve having times as abscissae and the reciprocal of the square root of the intensities as ordinates should be a straight line. Our observations thus plotted were found to be

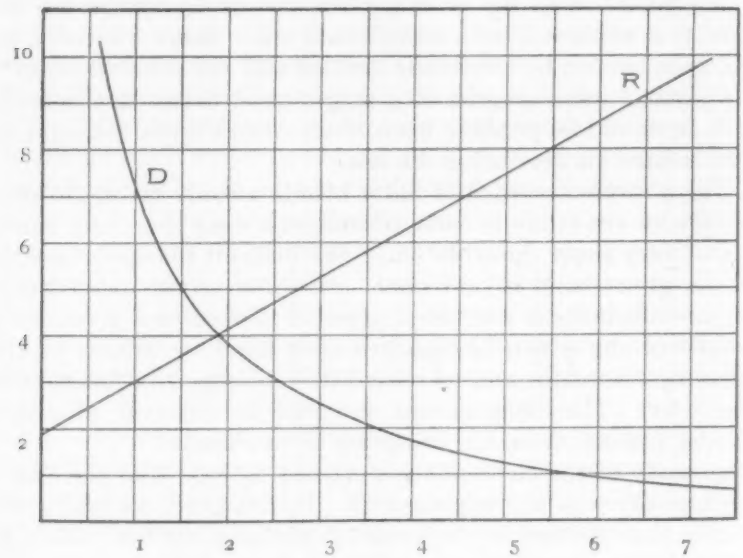

Fig. 4

in conformity with this hypothesis within the area of observation. In Fig. 4 one of these decadence curves (D) and the line of the reciprocals (R) is shown.

Knowing that the law of decadence for the various wave lengths of the green band is the same we then substituted for the spectophotometer a Lummer-Brodhun photometer, one side of the screen of which was coated with Sidot blende. The photometer carriage was mounted in a fixed position at one end of a long photometer bar and a standard light of suitable

intensity, consisting of an acetylene flame carefully screened and viewed through an aperture five mm. in diameter, was so mounted that it could be shifted to any desired position upon the bar.

A mercury arc lamp of the Lummer type served as an exciting source. The light from the mercury arc was passed through a color screen opaque to the green and yellow lines so that the exciting light consisted of those portions of the violet and ultra-violet spectrum capable of transmission through glass.

It was possible by this method to extend observations of the decadence curve of phosphorescence over the period of fifteen

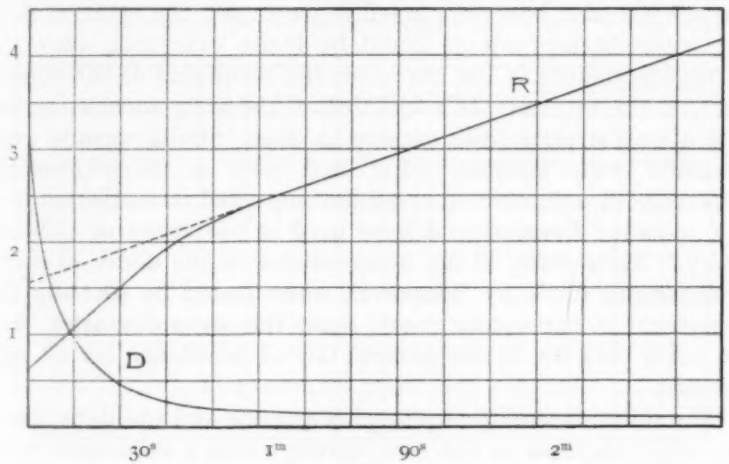

Fig. 5

or twenty minutes or nearly 100 times as long as in the observation of monochromatic light with the spectrophotometer. The curves thus obtained, which were plotted in the manner already described with the square root of the intensities as ordinates, exhibited a new and unexpected feature. Starting from the intercept the curves as before were straight for about ten seconds. They then turned more or less sharply downward, after which they again assumed the form of a straight line, but of different slope. It would appear therefore that in the decadence of the phosphorescence of this substance a rapid rate of decay is followed by another and slower decadence, both of which follow the law that the intensity is inversely pro-

portional to the square of the time. Fig. 5 shows a typical decadence curve (D) and the corresponding curve (R) for the reciprocal of fthe square root of the intensity. The diagram covers in interval of only two and a-half minutes. It refers to observations made after exposure of the Sidot blende screen for two minutes to the violet rays of the mercury lamp.

Experiments upon the decadence of the light emitted by a specimen of phosphorescent willemite gave results similar to those obtained with Sidot blende. The exciting source in these experiments was an electric spark between iron terminals and the luminescence immediately after the cessation of the spark discharge was quite as bright as in the case of the Sidot blende. Decadence was, however, much more rapid; the interval during which measurements could be made extending only for about one minute. The curve for the reciprocal of the square root of the intensity as a function of the time consists as before of two straight lines varying in slope. Similar results were obtained with Balmain paint and with a phosphorescent substance of unknown composition imported from Germany—the so-called *Emanations Körper* used in the study of radioactivity. Since many of the observations on the decay of phosphorescence made by Becquerel, when tested by plotting the reciprocal of the square roots, show the same character, it is probable that this is the general law of decadence for all substances.

The initial intensity of phosphorescence and the duration of the effect increase as the time during which a substance is exposed to light increases and continued exposure leads to a saturation such that further excitation is without effect. In Fig. 6 the initial phosphorescence of Sidot blende as function of the duration of exposure to the light of the mercury arc is shown. Complete saturation is not attained within the time limit of the diagram but the approach to it is obvious. The curve also exhibits the same in which the fluorescence of this substance gradually increases during excitation. There is during this period a storage of energy by the freeing of ions and these recombining after exposure give us the phosphorescence. The decadence curve is, however, not the counterpart of the curve for the growth of luminescence but the two related to one another in a manner curiously like that of the curve for the

rise of induced electromotive force in an electric circuit and the decadence of e. m. f. when the circuit is broken. Compare in this direction Fig. 6 and curve D in Fig. 5.

The effect of excitation upon the luminescent substance is to produce a curious instability which may be likened to that of iron subjected to the action of the magnetic field. If Sidot blende which has rested for several days in the dark be exposed to light for a time inadequate to saturation, say ten seconds, the decadence curve will have the form of Curve 1 Fig. 7. If it then be saturated the decadence observed will be represented by Curve 2. If, now, it be exposed again, for the same interval of time as in the first instance, the decadence will be much slower in consequence of the previous saturation. (See curve

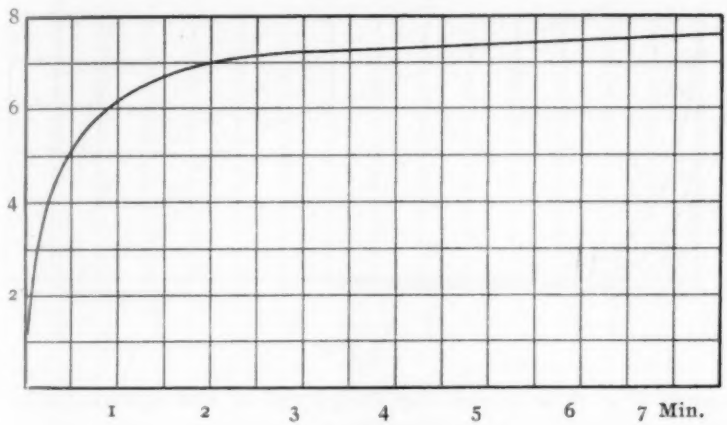

Fig. 6

3.) There is a certain retentiveness of luminescence and the effect of previous excitation to saturation shows itself for several hours. If, for example, the short excitation after saturation be delayed for several hours the substance will have drifted back into a condition more nearly like that in which it was after being in the dark for several days, but yet it will not have returned completely to the state attained after prolonged rest. As in the case of iron which has been magnetized and which loses its residual magnetism with time, a phosphorescent substance does not return to complete neutrality in accordance with any regular law. That is to say its condition even after

three or four days is not always the same. Other influences besides that of time appear to affect the state of the substance. Five minutes' subjection to a temperature of 100° C. will, for example, have more effect than several hours of darkness. Red and certain intra-red rays are still more effective. Light from an incandescent lamp after passing through ruby glass will in a few seconds change the condition of Sidot blende in such a manner that the decadence after ten seconds' exposure is much more rapid than is the case when the exposure is made after prolonged rest. (See Curve 4 of Fig. 7.) Whether rest in the dark would ever bring the substance into the condition to which it comes within a few seconds under the influence of red light has not yet been determined. These effects are better

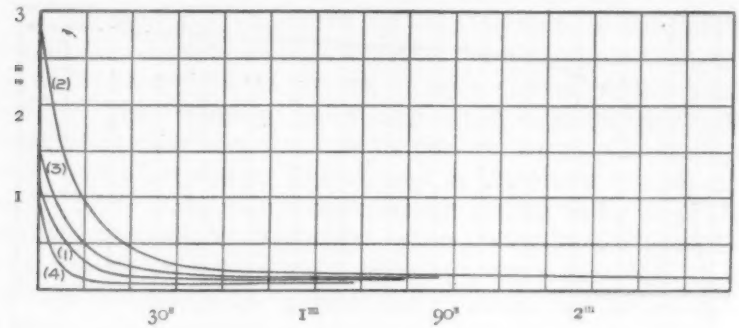

Fig. 7

seen in Fig. 8, in which the reciprocal of the square roots of these observations are plotted.

The phenomenon of retentiveness may be clearly exhibited by exposing a screen to red and then measuring the decadence after successive exposures to exciting light, each exposure being greater than the foregoing until saturation is reached after which a similar series of exposures each shorter than the foregoing are made. The curves for these shorter exposures after saturation do not correspond as to duration on account of the retentiveness of the substance and if a curve be plotted taking the reciprocal of the square root of the intensity in each case after a given interval of time, say three seconds, from the cessation of exposure with length of exposure as abscissæ, we get a curve analogous to a hysteresis curve for iron. (See Fig. 9.) The same phenomena as regards saturation, and retentiveness

are observed in the case of willemite, but the phenomena are less marked.

The effect of red and infra-red rays upon phosphorescence was first observed by Thomas Seebeck, the discoverer of thermo-electricity, whose observations were described by Goethe* in his Farbenlehre. E. Becquerel† and later his son, H. Becquerel‡ made an extended study of this subject and the latter used screens of phosphorescent material for the purpose of mapping the infra-red spectrum of the sun. J. W. Draper§

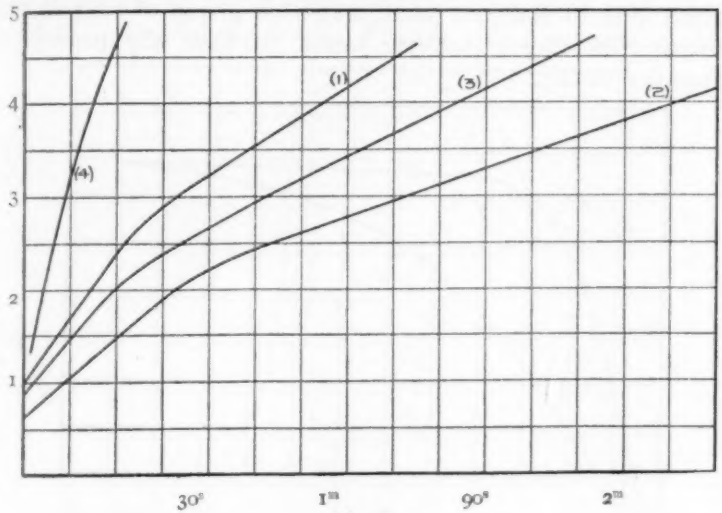

Fig. 8

in 1881 photographed the effect by submitting screens first to the action of the infra-red suectrum after which a contact photograph from the surface was taken. Fomm¶ made careful studies of the sun's spectrum by this method.

In 1904, Dahms‖ studied the effect of different parts of the spectrum upon previously excited phosphorescent surfaces, such as Balmain's paint, strontium sulphide with copper, zinc

*Goethe: Zur Fabenlehre III, page 55.

†E. Becquerel: Comptes Rendus 14, p. 903; 77, p. 30; 83, p. 243; also La Lumiére, Vol. I, p. 32.

‡H. Becquerel: Ann. de Chim et Phys. (5) 30, p. 1.

§Draper, J. W.: Phil. Mag. (5), Vol. II, p. 160.

¶Fomm: Wied. Ann. 40, p,. 681.

‖Dahms: Drude's Ann., 13, p. 425.

sulphide, and fluorspar. He found the action to be selective, not all wave lengths of the infra-red having the power to darken the phosphorescent surface. His photographs show an active region in the infra-red, followed in the case of Balmain's paint and zinc sulphide by a narrow inactive region. From the side towards the violet of this inactive band all wave lengths are effective in reducing the brightness of the surface until that portion of the spectrum is reached which is capable of producing phosphorescence. In certain cases, particularly that of Balmain paint, a limited group of rays in the extreme violet were likewise found to have the power to darken the surface.

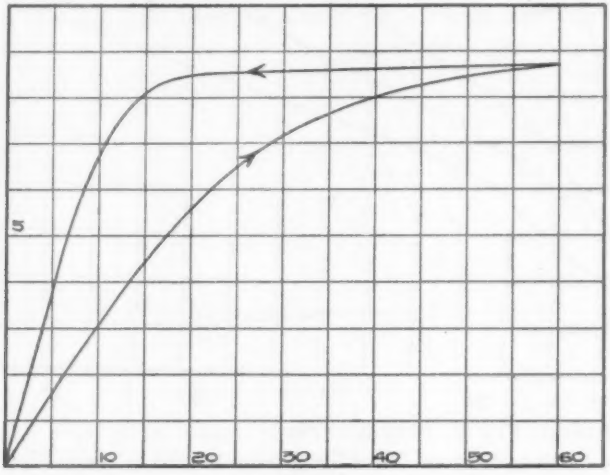

Fig. 9

Sidot blende is more strongly affected than other phosphorescent substances thus far studied, and it is easy by throwing upon a screen of this material, previously excited to phosphorescence, the spectrum from a source of light, such as the electric arc, to observe the phenomenon.

The calibration of Dahm's instrument did not extend to the infra-red and for the purpose of checking his results and of obtaining more definite information concerning the effect of this portion of the spectrum upon Sidot blende, Professor Merritt and the present writer have recently made measurements with the spectrophotometer upon the luminescent spectrum of this

substance; comparing the brightness of the same when exposed to a given wave length of radiation from a Nernst filament, with the intensity of luminescence when not thus exposed. For this purpose a mirror spectrometer was set up with quartz prism and monochromatic rays varying in wave length from .8μ to 1.6μ were thrown upon the luminescent surface under observation. The effect became easily measureable at wave length .8μ which even for this weak spectrum reduced the intensity of luminescence by 5%. It rose rapidly to a maximum at .9μ which was found to be the most active portion of the infra-red spectrum. The inactive band was located

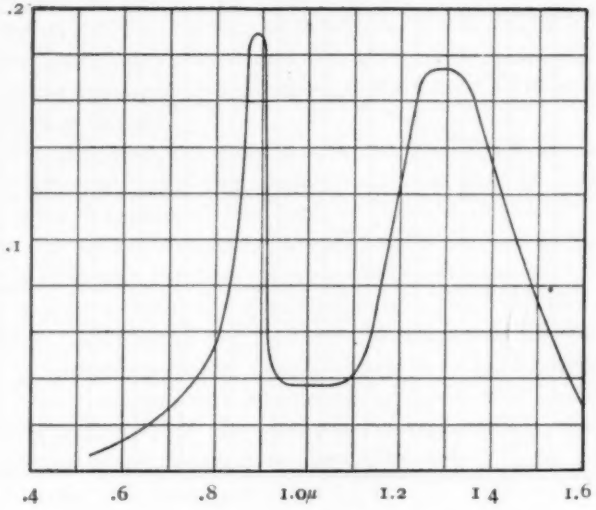

Fig. 10

as lying between .93μ and 1.1 μ, beyond which lies a second active region at 1.3μ. The results are shown graphically in Fig. 10.

When infra-red light is thrown upon a phosphorescent surface after excitation has ceased the effect manifests itself by an immediate change in the rate of decay. Upon the cessation of exposure to these rays the phosphorescent surface immediately returns to its original decadence, no after-effect of such exposure being apparent. Fig. 11 shows the decadence of a sidot blende screen excited to saturation, then allowed to de-

cay under normal conditions, 13 sec., at which time the light from an incandescent lamp behind ruby glass was thrown upon the screen for a few seconds then removed and then thrown upon the screen again. The effect is best shown in the curve for the reciprocal of the square root of the intensities (*a*, *b*, *c*, *d*, *e*.) The curve *a*, *b*, *f*, is the ordinary decadence curve.

Of the influence of temperature upon luminescence our knowledge is as yet fragmentary. We know in a general way that numerous organic substances such as paraffine, stearine, albumin and ethyl alcohol, which are not appreciably luminescent at ordinary temperatures, become so when cooled to

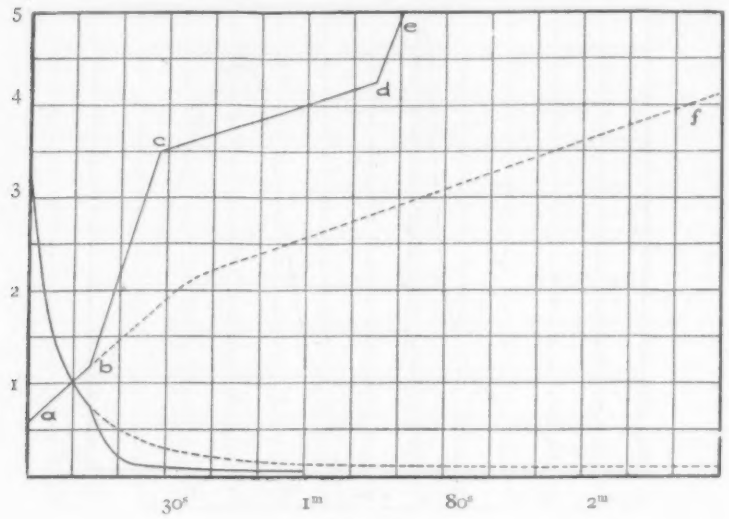

Fig. 11

about —190°C. The most striking experiments of this description, which was devised by Dewar, consists in cooling an egg in liquid air, breaking it open and exposing the albumin to the light of the electric arc. The blue glow which surrounds the yolk is very brilliant and remains visible in the dark for several minutes. The yolk shows no luminescence.

Other forms of albumen were tested in the course of an investigation of the luminescence of organic substances at the temperature of liquid air*. These showed only a feeble yel-

*Nichols and Merritt: Physical Review, 18, p. 355.

low phosphoresce instead of the fine blue of the white of egg. It is probable that the luminescence of the latter substance is due to traces of some dissolved metal; the albumin being merely the solvent.

Certain substances such as phthalic anrydride, anti-pyrin, salicylic acid, arsenious oxide, and benzoic acid show their most intense phosphorescence at temperatures somewhat above —190°C*.

Many phosphorescent substances, after exposure to light, glow for a time when suddenly heated. This phenomenon, *thermo-luminescence,* appears to be due to an unlocking of previously stored energy by heat. That there is no transfer of heat energy into the energy of luminescence is probable since the effect is temporary and since the glow cannot be obtained by subsequent heatings unless the substance be first subjected to its proper stimulus.

In this paper many aspects of the subject have been altogether ignored. To the extensive researches of Lenard and Klatt, who determined the type of phosphorescence produced by the solution of various metallic salts in a variety of solid solvents only the briefest reference has been made. The effect of fluorescence upon the absorption of light by the fluorescing substance, discovered by Burke† for canary glass and subsequently confirmed in the case of various organic liquids‡, has not been considered nor has anything been said about the related phenomenon of the increase in electrolytic conductivity of solutions when excited to fluorescence¶. Both effects, although experimentally established by the investigators cited, have since been sought for by Carmichael§ without success.

Other recent investigations, the discussion of which is beyond the limits, as to space, of the present paper, are those of Morse||, who has shown that in addition to the usual continuous fluorescence spectrum certain specmens of fluorite under powerful illumination have well defined line spectra of fluorescence.

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*Nichols and Merritt: l. c.

†Burke: Phil. Trans. 191 (A) p. 87; Proc. Royal Soc., 30 III, 1905.

‡Nichols and Merritt: Physical Review, XIX p. 396.

¶See Nichols and Merritt: l. c.

||Morse: Astrophysical Journal, 21, p. 83.

Radiation of this character from solids is altogether foreign to previous experience and no adequate explanation has as yet been found unless indeed the suggestion put forward by the author be substantiated, that the spectra have their origin in gases occluded within the crystals. This view finds support in the very remarkable fluorescence spectrum of sodium vapor described by Wood* who has obtained, by varying the conditions of the experiment, in place of the fluorescence spectrum first observed by Wiedemann† a line spectrum of great complexity.

In luminescence we have one of the most important branches of the science of radiation. For many ears it has been one of the most neglected branches of that science. Our knowledge of the phenomena is far complete and no satisfactory theory has as yet been established. The older and simpler views of the constitution of matter were indeed inadequate for such speculations and it was impossible to form any definite conception of a plausible mechanism to account for the observed facts. With the new hypotheses of matter already developed to account for the phenomena of solution, electrolysis, dissociation and radioactivity at our service this difficulty no longer exists. We can now imagine various intramolecular processes to account for isolated facts and even groups of facts of luminescence and suggestions looking to a theory have been formulated by Wiedemann and Schmidt, Voigt and others. A vast amount of quantitative work, however, remains to be done before anything like a complete theory is likely to be presented, or if presented can possibly be confirmed in all its details. Theory building in such a field as this will inevitably lead physicists to further insight into the nature of matter and thus ultimately to practical applications in a department of physics which at present appears to be of purely scientific interest.

Physical Laboratory of Cornell University, March, 1906.

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*Wood: Phil. Magazine (6) 6 p. 362.

†Wiedemann: Wiedemann's Annalen, 57, p. 447.

THE PRODUCTION OF FLUORSPAR IN 1905.

The total production of fluorspar in 1905, as reported by Mr. Edmund Otis Hovey, of the United States Geological Survey, was 57,385 short tons, valued at $362,488, most of which came from the mines in Illinois and Kentucky. This is an increase of 20,933 short tons in quantity and of $127,733 in value, as compared with 36,452 short tons, valued at $234,755, in 1904. The production, furthermore, is greater than ever before, surpassing the previous record year, 1902, by 9367 short tons in quantity and $90,656 in value. The companies report such active demand for fluorspar, particularly for use in open-hearth steel furnaces, that the production of 1906 is likely to exceed greatly that of 1905. The operators in Illinois and Kentucky are seriously hampered in working their mines by the difficulty of getting reliable and competent workmen.

The Illinois production amounted to 33,275 short tons, valued at $220,206, an increase of 16,070 short tons in quantity and of $98,034 in value over the reported production of 17,205 short tons, valued at $122,172, in 1904. Kentucky has fallen to second place, the output in 1905 being 22,694 short tons, valued at $132,362. This, however, is an increase of 3598 short tons in quantity and of $20,863 in value as compared with 19,096 short tons, valued at $111,499, in 1904. In Tennessee, 25 tons of fluorspar were mined, but not sold.

THE PRODUCTION OF PRECIOUS STONES IN 1905.

While the United States may never lead the world in the production of gems, the value of its output of precious stones in 1905 reached the very respectable figure of $326,350.

The largest output is from the sapphire mines, the yield of which amounted to $125,000. Next in value are the turquoise, quoted at $65,000. Then come the tourmalines worth $50,000. Peridotes, crystal quartzes, and miscellaneous stones are accredited with a value of $10,000 each. The production of aquamarines is valued at $6,000, of kunzite, gold quartz, chrysoprase, silicified wood, and garnet at $5,000 each, of smoky quartz and chlorastrolite at $3,000 each, of amethyst, agate, pyrite, malachite, anthracite, and catlinite at $2,000 each, of moss agate at $1,500, of beryl, rose quartz, amazon-stone, and arrow points at $1,000 each, of topaz, utahlite, and mesolite at $500 each, of fossil coral at $250, and of dumortierite in quartz at $100.

Mr. George F. Kunz, who has prepared a report entitled, "The Production of Precious Stones in 1905," which will soon be published by the United States Geological Survey, is authority for these figures.

AMERICAN AMETHYSTS.

From time to time amethysts are discovered in North Carolina, says Mr. George F. Kunz, of the United States Geological Survey, in a forthcoming report on precious stones. They are found especially in the region of Rabun Gap, Georgia, on the North Carolina border. No quantity sufficient to warrant mining seems to exist. Yet many of the stones are incomparably beautiful, second indeed to none found in foreign localities.

THE GREATEST GEM MINE IN THE WORLD.

The sapphire workings at Yogo Gulch, Montana, are being gradually developed into a great and permanent mining industry, says Mr. George F. Kunz in a forthcoming report on precious stones, published by the United States Geological Survey. Taken as a whole, the Yogo dike is perhaps the greatest gem mine in the world. It is about 4 miles long on the surface, and being a true igneous dike, descends to an indefinite depth. It is estimated that the entire content of workable sapphire-bearing rock would approximate 10,000,000 cubic yards. A mining plant is now being erected here which will quadruple the previous output and make Montana sapphire mining a very important factor in American gem production.

The stones obtained are not of large size. They range from "culls," used for watch jewels and other mechanical purposes, to gems averaging, when cut, from half a carat to 2 or 3 carats and rarely up to 5 or 6. As gems they are brilliant, free from flaws and of good color, ranging from light shades to the rich, deep blue of oriental sapphires. The Yogo crystals have an advantage for mechanical uses over East Indian stones in their form, which is largely short prismatic or rhombohedral with flat basal terminations, and hence they need much less cutting for such purposes as watch jewels. The gems are sent to Amsterdam for cutting, and yield from two-fifths to one-half that weight of finished stones.

ABRASIVE MATERIALS.

The United States Geological Survey is about to publish its annual report on the production of abrasive materials during 1905. The report takes note only of that small part of the production of these materials which is actually used for abrasive purposes.

The aggregate value of the production of the natural abrasive materials during 1905 was $1,427,780, which is an increase of $20,679, as compared with $1,407,101, the value of the 1904 production. This includes oilstones and scythestones at $244,346, grindstones and pulpstones at $777,606, buhrstones and millstones at $37,974, pumice at $5,540, infusorial earth and tripoli at $64,637, crystalline quartz, including feldspar, at $88,118, garnet at $148,095, and corundum and emery at $61,464.

There is considerable variation from year to year in the value of the different abrasive materials, and this represents in nearly all cases a corresponding variation in the quantity produced. As a rule, however, the actual quantity of abrasive materials produced and put on the market in one year is increasing.

The value of the artificial abrasive materials—such as carborundum, crushed steel, and alundum—manufactured during 1905 is estimated at $701,400, as compared with the estimated value of $830,926 of the 1904 production, a decrease of $129,526. This, however, is a large increase as compared with $493,815 in 1903, and with $390,245 in 1902.

The report was prepared by Mr. Joseph Hyde Pratt.